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ILLINOIAN DRIFT REGION OF NORTHEAST CENTRAL OHIO

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INTRODUCTION

The purpose of this paper is to discuss the pre-Wisconsin drift region in northeast central Ohio, including northeastern Licking, southwestern Coshocton, eastern Knox, southeastern Richland, and southwestern Ashland counties, (Fig. 1).[1] This area is the northern part of the area of Illinoian drift, which lies east of the Scioto lobe of Wisconsin drift and south of the Killbuck lobe (9, Fig. 1)[2] of Wisconsin drift. To the north, the Illinoian drift occupies the re-entrant angle between these two Wisconsin lobes. The area lies wholly within the Allegheny Plateau which was here dissected to maturity, and which had a relief of 200 to 400 feet before Illinoian drift masked the pre-Illinoian erosion topography in varying degrees—at most places but slightly, but at some, however, mainly in wide valleys, it effectually covers the bedrock topography and controls the topographic expression.

CORRELATION

The drift of northeastern Licking, southeastern Knox, and southwestern Coshocton counties was described as Illinoian by Leverett who traced the Illinoian drift from Illinois across Indiana and southern Ohio to this area (2, pp. 253-261). His correlation is used here. Although Leverett regarded the drift of much of northeastern and north central Knox County as Wisconsin, the studies of the present writer show that this drift has the same characteristics as, and can be traced directly into, the drift of southeastern Knox County. It must, therefore, be Illinoian, and is so shown on the map, Fig. 1.

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[1] The topographic maps of the area are Shauk, Perrysville, Loudonville, Gambier, Brinkhaven, Newark, and Frazeysburg.

[2] References are to bibliography at end of paper.

THE TILL

The unoxidized, unleached, fresh Illinoian till is a strongly calcareous, bluish gray, pebbly clay, of a somewhat silty character. Pebbles and cobbles are common, but boulders are rare. Few boulders larger than two feet in greatest diameter were seen. The percentage composition of one half

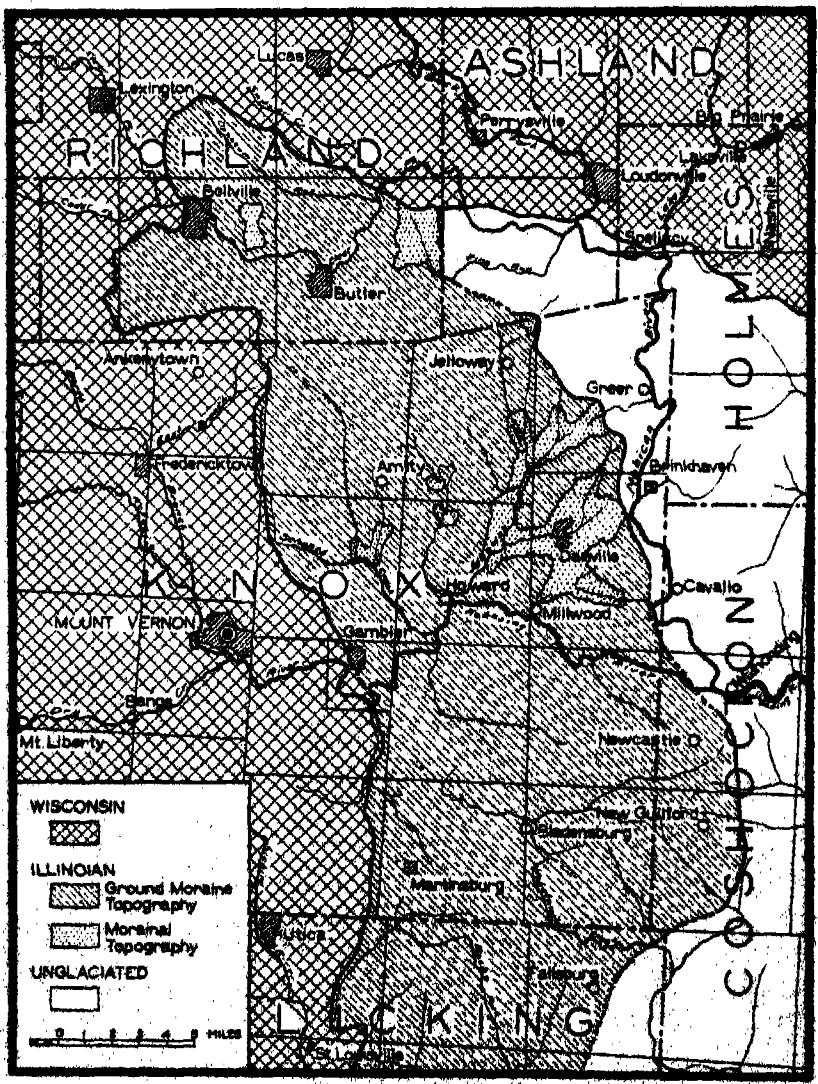

FIG. 1. Map showing glacial geology of a part of north central Ohio.

to two inch pebbles from unaltered till in northeastern Section 7, Perry Township, Coshocton County, was determined as:

Limestone	46
Sandstone	32
Carbonaceous shale and coal	7
Flint	6
Granite	2
Quartzite	7
	100

The limestone, constituting 46 per cent, came from southern Ontario or the Erie basin. The sandstone, carbonaceous material and flint came from the Waverly and Pottsville formations of the Allegheny Plateau and travelled from one to a maximum of 40 miles. The igneous and metamorphic material came from the Canadian Shield.

The upper part of the till is at all places altered by agencies of weathering. A trustworthy average section of the weathered upper part can hardly be given, because comparatively few exposures reveal the unaltered till, but the following section is based on the data at hand:

		Feet
ZONE 3.	Till: light brown, porous, oxidized, leached Sharp contact with Zone 2.	8
ZONE 2.	Till: brown, oxidized, unleached Irregular gradation into Zone 1.	7
ZONE 1.	Till: grayish-blue, silty, calcareous, moderately hard, pebbly	0–25+

Zone 1 is the unaltered unoxidized, unleached till that has been described. Zone 2 is the oxidized, unleached zone and Zone 3 is the oxidized, leached zone which grades into soil near the surface.

The oxidized Illinoian till of Zone 2 is brown, the exact shade varying from medium to light, depending on the amount of moisture present. This oxidized, unleached zone has a thickness of from 6 to 12 feet and grades with an uneven contact into the unoxidized blue till below, the oxidation having advanced more rapidly where the till is more porous. It is similar in texture and mineral content to the blue till of Zone 1. This unleached, oxidized zone in the till of Illinois has been called "Horizon 4" by Leighton and MacClintock (1).

The leached, oxidized Illinoian till of Zone 3 is light brown in color, the shade decreasing in intensity toward the surface. This zone is looser and more porous than Zones 1 and 2, because of the solution of limestone pebbles and finer calcareous material and of the entrainment of finer rock particles by ground water.

This leached zone has a thickness of from 5 to 15 feet, and rests with a sharp contact upon the oxidized, unleached zone below. In Illinois (1, Fig. 1), this zone has been divided into Horizons 1, 2, and 3, but in that part of Ohio here discussed the distinction between "Horizon 2" and "Horizon 3" is not immediately apparent, in part, possibly, because the till is so well drained.

The thicknesses of Zones 2 and 3 vary greatly from place to place because oxidation is faster in more porous till and in those portions having better drainage, and to the removal of the oxidized zone by erosion at the surface. On steep slopes this removal may keep pace with, or exceed, leaching. The following section was observed on the road cut along the state highway in the northeastern part of Section 7, Perry Township, Coshocton County, one-fourth mile northeast of New Guilford:

	Ft.	In.
Soil and silttil (1, p. 41): dark brown, sandy, leached	2	10
Clay: brown, pebbleless, leached	0	6
Clay: gray, pebbleless, leached	1	1
Clay: gray, pebbleless, unleached	0	6
Till: brown, only moderately pebbly, silty, oxidized, unleached	6	4
Till: dark blue, silty, only moderately pebbly; grades into above fairly sharply	4	0

This section is only one-half mile west of the glacial boundary and is unusually thick for a location so close to the glacial border.

Along the Martinsburg-Bladensburg state road in Clay Township, Knox County, one and one-half miles west of the village of Bladensburg, the following section was measured:

	Ft.	In.
Soil and Silttil: buff to ashen, fine-grained, silty; much weathered	1	6
Till: brown, silty, thoroughly oxidized, leached, pebbly; grading upward to yellow; with some dark stains along joints in lower part	4	0
Till: yellow-brown, sandy, very pebbly, unleached; with white spots and limestone pebbles	5	4
Till: gray-blue, sandy, pebbly, unleached	2	0

In a new road cut along the Mt. Vernon-Coshocton road in western Howard Township, one-quarter mile east of Monroe Mills, 12½ feet of yellow, leached, porous till, with many sandstone cobbles and pebbles included, resting on Waverly (Blackhand) sandstone, were exposed. This is more than usual depth of leaching and is attributed to the fact that here the till is quite sandy and porous. The variation in depth of leaching over short distances, especially where erosion may have been active on slopes, is shown by the following section measured along the same road one mile west of the above exposure:

	Ft.	In.
Till: yellow, sandy, leached	4	6
Till: yellowish-brown, silty, hard, unleached	7	6
Till: blue-gray, hard, pebbly, strongly calcareous	5	0

A section measured in a newly excavated road cut one-half mile east of Amity in eastern central Section 21, Pike Township, shows only five and one-half feet of unleached till, and indicates that part of the leached zone has been removed. The section is as follows:

	Ft.	In.
Till: yellow, weathered, leached	5	6
Till: yellowish-brown, silty, strongly calcareous	6	6
Till: dark blue, silty, pebbly, strongly calcareous	1	0

The leached zone is from seven to over twelve feet thick in Pike and Brown townships in northern Knox County. In Jefferson and Union townships, northeastern Knox County, the depth of leaching varies generally from six to eight feet. Probably the till here has suffered more erosion, and the surface is now being eroded away faster than leaching can penetrate downward.

The Illinoian till is thin and discontinuous in much of Worthington and eastern Jefferson townships of Richland County. It is thicker and more generally present in central and central western Jefferson and central southern Washington townships, where deep exposures may disclose unaltered blue till. An excellent section was exposed by the relocation of the Bellville-Mansfield state road, two miles north of Bellville in central Section 4, Washington Township, where the following divisions were measured:

		Ft.	In.
6.	Soil: buff to ashen gray, strongly weathered, silty, almost pebbleless	2	0
5.	Till: very dark brown with black stains along joints, with some pebbles, leached, strongly oxidized	2	3
4.	Till: yellow-brown, leached, oxidized, sandy with pebbles; becomes more buff upward and grades into No. 5	6	4
3.	Till: brown, hard, oxidized, unleached, very pebbly; with darker stains along joints and an uneven contact with No. 2	6	6
2.	Till: gray-blue, hard, unevenly oxidized along joints	4	0
1.	Till: blue, hard, pebbly, with boulders up to 4 feet in diameter; to road level	15	0

It may be noted that 1 and 2 correspond to "Horizon 5," and 3, 4, 5, and 6 to "Horizons" 4, 3, 2, and 1, respectively (1).

ILLINOIAN BOUNDARY

The outer limit of Illinoian drift extends in a general northerly direction across Licking County, swings eastward to include the southwestern part of Coshocton County and thence northwestward across northeastern Knox and southwestern Ashland counties to disappear underneath the Wisconsin drift in southeastern Richland County.

The Illinoian boundary varies in distinctness. In some places it is marked by continuous drift which influences the topography; in places by only scattered boulders and pebbles; and in still other places it is only conjectural and must be mapped by extending a line between two known points. Road cuts, ravines, and fields were carefully examined, and, in order to be sure that the most eastern foreign pebbles or cobbles were actually found, a belt of from two to more than five miles beyond the boundary was carefully searched.

The Illinoian boundary shown on the map, Fig. 1, agrees with that of Leverett (2, pl. 13) in Licking and southwestern Coshocton counties, but to the north the present investigation shows the Illinoian boundary to be considerably west of that mapped by Leverett. Extended search failed to bring to light any glacially derived material east of the Mohican River in northwestern Coshocton County or in southwestern Holmes County, (4, p. 437).

Licking County.—The Illinoian boundary in that part of Licking County included in Fig. 1, crosses from the northern part of Perry Township into Fallsbury Township which it crosses in a northeasterly direction to the corner of that township. The boundary from the great glacial dam at Hanover to Fallsburg in northeastern Licking County is exceedingly vague. Erosion has removed almost all of that Illinoian drift not only from the region near the mapped boundary, but from the territory several miles to the west. Indeed, the Illinoian drift found closest to the conjectural boundary mapped south of Fallsburg, was one mile north-northwest of Hickman in northern Mary Ann Township and in central Section 21, Eden Township. It may be possible that south of Fallsburg the Illinoian boundary as drawn is too far east.

One mile northeast of Fallsburg, in northwestern Section 12, Fallsbury Township, a few cobbles and pebbles of resistant foreign rocks, found on the north side of a road cut, are taken as the limit of ice advance; the location of these is shown in

Fig. 1 by a solid line. Northeast from this locality for several miles, the boundary is again indistinct.

Coshocton County.—The boundary enters Coshocton County in the southwestern corner of Perry Township and passes northeastward to Winding Fork. Thence it passes in a general northerly direction across Perry Township into Newcastle Township to the edge of the upland south of the Walhonding River. Across these townships the drift extends almost, or quite to the boundary at numerous places, although it becomes quite thin along the outer margin.

One-half mile east of Newcastle the boundary turns sharply to the northwest and passes into a more rugged area along the Kokosing valley for two and one-half miles northwest to the Coshocton-Knox county line, one-half mile north of the Kokosing River. Erosion has removed all the drift from the steep valley walls of the Kokosing valley, and even from the narrow interstream areas, so that foreign pebbles are absent for some distance back from where the ice margin rested, as mapped by a broken line on Fig. 1.

Knox County.—North of the Kokosing valley the Illinoian boundary lies only one to two miles west of the Mohican River valley for a distance of about ten miles. The Illinoian ice margin was apparently the factor which determined the location of this part of the Mohican River (8). The boundary enters Knox County in the southeast corner of Union Township in Section 21, where igneous pebbles exist along the top of the ridge. North of Section 21, the boundary is indefinite for about three miles to Tager Valley, where areas with constructional topography make a fairly definite boundary. Thick deposits of drift mark the boundary northward into Jefferson Township. In Section 8, Jefferson Township, the border crosses a preglacial valley, and its course is especially clear in central and northwestern Section 8, where gravel knolls are prominent at the border (Fig. 2). Thence the drift limit runs in a general northwesterly direction to the northeastern corner of Brown Township.

In the northeast corner of Brown Township, one and one-half miles northeast of Jelloway, a morainic ridge, about a mile long extends across a preglacial valley and forms a water parting in the old valley. The drainage of the portion to the northeast was diverted during the ice occupancy southward across a former divide to Shadley Valley Creek. The Columbus-

Cleveland highway crosses the south end of this moraine one and one-half miles northeast of Jelloway, and for one-half mile northeast the highway skirts the pre-Illinoian valley which is dammed by the drift ridge.

Ashland County.—From the northeastern corner of Brown Township, Knox County, the boundary runs north-northwest across southwestern Hanover Township, Ashland County, to the west line of Section 19, on the Ashland-Richland county line. The boundary is indefinite and may be mapped only by examining the fields and road cuts for foreign pebbles, there being no till for a mile or even two miles or more inside the boundary.

Richland County.—The Illinoian boundary in Worthington Township is located just west of the county line. A considerable thickness of Illinoian drift extends almost or quite to the boundary which is topographically distinguishable against the hills to the east. The Illinoian boundary passes under the east-west trending Wisconsin drift boundary in western central Section 12, about 300 yards west of the county line. Here the overlapping of the Wisconsin moraine makes separation of the moraines of the two ages very difficult.

THE ILLINOIAN-WISCONSIN BOUNDARY

The inner boundary of the Illinoian drift region is the outer boundary of the Scioto lobe of the Wisconsin drift region. It is 10 to 13 miles west of, and roughly parallel to the outer boundary of the Illinoian drift (Fig. 1). The northern boundary of the Illinoian area is made by the overlapping edge of the Killbuck lobe of the Wisconsin drift sheet. Brief descriptions of these boundaries have been published (6, 7).

AREAS OF GROUND MORAINE TOPOGRAPHY

The Illinoian drift region is in large part an area of ground moraine (Fig. 1), but small areas of morainal topography and of kames and kame terraces are present. Most of the area consists of a maturely dissected bedrock topography with a veneer of drift which mantles the surface and forms minor relief features. In some localities the pre-Illinoian bedrock topography is more masked than in others. In many localities drift was either never deposited or has been considerably eroded from hilltops. Most of the Illinoian drift region here described falls generally in MacClintock's type 3 (3, Figs. 2 and 8).

FIG. 2. Kames near Illinoian boundary in central Jefferson Township, Knox County, two miles southwest of Greer. Bed-rock hills in distance with thin veneer of till.

FIG. 3. Illinoian ground moraine one mile southeast of Newcastle, Coshocton County.

Fig. 4. Knolls of Illinoian drift in northwestern Jefferson Township, Richland County, two miles east of Bellville. The most distant hills are only thinly covered with drift.

Licking County.—The eastern part of Washington Township and the western part of Eden Township are quite generally drift covered, although bedrock frequently outcrops in gullies and along the roads, especially near the tops of the hills. In eastern Eden Township and western Fallsbury Township, the drift is very thin and discontinuous, and confined to scattered boulders and small masses of till on the ridges. A little kame gravel is present in the valley of Long Run, central Section 21, Eden Township. Swells of gravelly till are present along the county line in Section 2, Eden Township.

Coshocton County.—The glaciated part of Coshocton County is more generally till covered than is the territory nearest the glacial boundary farther to the southwest. Indeed, the till is so thick in parts of these townships, that the topography has been somewhat subdued by the drift control. The surface is rolling in long smooth sweeps. The relief varies from 50 to 100 feet, the slopes commonly having a grade of 100 feet or less per mile except along the valleys of the eastward flowing streams where the relief is more pronounced. Fig. 3 shows a part of this rolling plain south of Newcastle.

Knox County.—The Illinoian surface of that part of Knox County south of the Kokosing River offers considerable contrast to the Illinoian surface north of the river. The surface is generally till covered, and in many places, especially in the valley of Wakatomika Creek, constructional topography is evident. Bedrock is exposed, however, on many of the slopes, which is in distinct contrast to the Wisconsin drift region to the west where the till is a great deal thicker and where bedrock is much less generally exposed.

The Illinoian region is much more rugged north of the Kokosing River than the rolling areas south of the river. Three factors seem to be responsible: (1) the pre-Illinoian surface was an area of mature dissection having a bedrock relief of 200 to 400 feet and possibly somewhat greater; (2) only enough till was deposited in most places to veneer the bedrock topography; and (3) the greater relief, and steeper slopes of the bedrock topography have allowed erosion to remove much of the thin till sheet that was deposited. In a few small areas sufficient drift to cover the bedrock remains, making rolling areas of small extent.

In Union, Howard, southern Brown, and southwestern Jefferson townships the drift is generally discontinuous, except in certain valleys where morainal areas exist. The general aspect is one of wide valleys with undulating till surfaces, flanked by valley slopes, commonly of bedrock. The hilltops preserve evidence of glaciation—till where they are broad, but only foreign cobbles and boulders where they are narrow. In Monroe and Pike townships the Illinoian drift is more continuous although bedrock often appears at the surface on the upper slopes and hilltops. In the central part of Pike Township, in the headwaters of Little Schenck Creek, the slopes are more undulating than is common, and the topography is quite constructional. The till here is unusually gravelly. To the north, in the vicinity of North Liberty, the till is thick and somewhat gravelly. Here is an upland area of about one-half a township that has thicker till and more billowy surface than usual, being similar to the area south of the Kokosing River.

Richland County.—In the Illinoian area in Richland County the till is generally thin and discontinuous except in the Davis Basin and in a few of the valleys. An area east of Butler (2, pp. 393-394) has been described as driftless, but the present writer has found scattered boulders and occasional till patches in this area in southern Worthington Township. In Jefferson Township both north and south of Bellville, the Illinoian drift is thicker than it is to the east. Considerable drift, sometimes with an undulating surface, remains in the valleys and even on some of the hilltops.

AREAS OF MORAINAL TOPOGRAPHY

Only a few areas showing definite morainal topography exist in the Illinoian drift region and these areas are almost entirely confined to wide pre-Illinoian lowland areas mostly near the Illinoian border (Fig. 1). It is believed that morainal topography was rarely, if ever, developed on the uplands of this rugged area. This interpretation is supported by the fact that in those parts of the Wisconsin region which are equally rugged, morainal topography is usually found only in the old valley areas (4, 5). The position of these depositional features in the old valley courses, from which the pre-Illinoian streams were in most cases diverted, has protected them from active erosion such as similar features would have suffered on the higher slopes or over the upland, and has permitted constructional features to persist to the present. Their preservation was still further aided by the gravelly character of the morainal drift which allows greater percolation of the rainfall, thus preventing excessive surface erosion.

These irregular areas of Illinoian morainal topography are explained by the writer as deposits made by melting of stagnant ice, and not as end moraines. They are similar to previously described Wisconsin morainal deposits in similar topographic positions (4, 5).

Danville Area.—The largest area of Illinoian morainal topography is in a plexus of wide pre-Illinoian valleys in northeastern Knox County, in Union, and southwestern Jefferson townships. The topography is indeed unusually morainal for Illinoian, and Leverett (2, p. 383) described it in 1902 as Wisconsin terminal moraine. An Illinoian age is indicated, however, by the fact that the region between this morainal area and the Wisconsin boundary shown on Fig. 1 is discontinuously mantled by typical Illinoian ground moraine.[3]

West and southwest of Danville, on either side of the valley of East Branch, low swells of gravelly till are plastered against the valley walls to a height of about 100 feet above the wide valley bottom. Above this height bedrock outcrops are common. The unnamed valley from Danville south to Millwood is filled with kames and with swells of sandy till containing pockets of gravel. To the southeast of Danville a prong of the moraine extends over into the headwaters of Flat Run and continues to within less than two miles of the drift border. The sides and bottom of the valley of Flat Run from its head almost to Flat Run School are covered with low swells, made up of silty till with some pockets of gravel.

A group of conspicuous kames, some of them 100 feet high, cover about a square mile of the area one to two miles south of Danville. The gravel is medium-grained at places and coarse at others, with many six- to eight-inch cobbles and a few boulders up to two feet in diameter.

The valley of East Branch northeast of Danville is moderately broad and the slopes have a constructional topography. Many sections of till are exposed along the Danville-Greer road, but most of them are not deep enough to expose unaltered blue till.

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[3] Similar extensive areas of morainal topography of Illinoian age are well developed in the valley of Jonathan Creek in southwestern Muskingum County and northeastern Perry County.

Broad swells with a relief of 20 to 30 feet begin one to two miles east of Danville, south of the railroad, and extend east to the glacial boundary. Here several large kames rise from 50 to 100 feet near the glacial boundary. The gravel composing them is cobbly to medium-grained gravel, with some pockets of fine gravel and sand. The bedding is irregular and slumped, and it dips at high angles in various directions. Large masses of blue, silty till are included in the gravel. Eastward from these kames, for about three-fourths of a mile between the Pleasant Valley School and the southwestern corner of Section 22, Wisconsin outwash has filled the Mohican valley and probably slightly overlaps the Illinoian drift. Though this outwash might appear to be associated with the Illinoian terminal moraine, investigation shows very definitely that it is a part of a Wisconsin valley train deposited in the Mohican valley. Remnants of this valley train can be traced from the Wisconsin boundary, north of the Knox-Holmes county line (4, Fig. 2), southward to the mouth of the Mohican River, and thence down the Walhonding valley.

Morainal topography is well developed in the wide valleys of Jelloway Creek and its tributary, Dowd Creek, in eastern Brown and southwestern Jefferson townships. Knolls partly fill a pre-Illinoian valley carved by a stream which rose east of Greer and flowed southwest. These deposits form the present water parting between the westward flowing east fork of Dowd Creek and a small eastward flowing tributary to the Mohican River which now drain the valley. Morainal topography is especially well developed in Section 14, southern Section 7, and southwestern Section 8, where the knolls rise 40 feet or more. In southwestern Section 7, a few small kame-like knolls 20 feet high are made up in large part of dirty, poorly sorted, subangular gravel in which till masses are included. At the Illinoian boundary in the northwestern central part of Section 8, well developed kames from 30 to 50 feet high cover an area of about one-fourth square mile (Fig. 2), choking a pre-Illinoian valley and causing a minor stream diversion.

Other Areas in Knox County.—Well developed constructional topography, consisting of rounded knolls 20 to 30 feet in height banked against the valley sides, exists in a small area of about one square mile along the northeast side of the valley of Schenck Creek in northeastern Monroe Township. The area extends northward for a little more than a mile up the valley of Coleman Branch and northwestward to the mouth of Little Schenck Creek. Cobbly gravel is present on either side of Coleman Branch about one-half mile north of its junction with Schenck Creek. The till of the northern part of this area is very bouldery as is the till of the ground moraine farther northward.

An oval shaped area of rounded drift knolls, one-half mile long and one-quarter mile wide, is crossed by Little Jelloway Creek just south of the Brown Township line in northwestern Howard Township. About a mile to the north is a slightly smaller moraine area in central Section 24, Brown Township. It rises about 40 feet above the valley floor. Little Jelloway Creek detours around it through the hills, the stream returning to its old valley one-half mile south of the till dam. The surface is undulating to hummocky and quite constructional in appearance.

The Davis Basin.—This is a rectangular area about three miles northeast of Butler, covering about three square miles in Sections 13, southern 12, eastern 14, and southeastern 11 in eastern Worthington Township, Richland County, just west of the Ashland County line. The name, not on the map, is derived from the tiny hamlet formerly known as "Davis Post Office" at the crossroad on the line between sections 12 and 13. The surface is gently undulating rather than hummocky, except in the northeastern Section 14, where rather smooth, gravelly knolls 10 to 20 feet high are present. The floor of the basin rises from an elevation of 1,220 feet in the central part to about 1,300 feet at the borders. The basin is bounded on the east by unglaciated bedrock hills, on the south and west by bedrock hills on which glacial deposits are very meager, and on the north by Wisconsin moraine. The material is silty till, except for the gravel knolls in Section 14, and for a small area of dirty gravel in central Section 13. Till continues to within 200 yards of the glacial boundary, just west of the county line.

Northeastern Jefferson Township, Richland County.—Drift with fairly definite constructional topography partly fills the valley of a small southward flowing tributary to Clear Fork in central Section 11 and central southern Section 2. Pronounced drift knolls are banked against the hillside just north of the road forks at the line between the two sections (Fig. 4). The till is quite variable in this small area, ranging from silty, through sandy, to gravelly clay. Brown, leached, pebbly till is exposed in a cut 12 feet deep along a road just northeast of the road forks. The pebbles are so greatly weathered that many of them break with a light blow of the hammer.

AREAS OF KAME TOPOGRAPHY

Small areas of kame-like hills are associated with the larger areas of morainal topography at several places in western Knox County and have already been mentioned. Kame-like knolls, aggregated in the form of kame terraces, are also present at two places in the Kokosing valley. These benches made by kames that rise to a general level are quite similar to the more extensive Wisconsin kame terraces in valleys in the Allegheny Plateau (4, 5), and are believed to be remnants of Illinoian kame terraces.

An area of kames nearly one-half square mile in extent exists about one mile west of Millwood in eastern Howard Township along the north side of the Kokosing valley. Gravel hills are banked against the valley wall, making a rude terrace bench that rises to an elevation of 1,040 feet, although mostly below 1,000 feet. The gravel is variable in texture, ranging from medium-grained to cobbly, and apparently includes some till masses. To the north the gravel grades into gravelly till which conceals the bedrock up to an elevation of 1,100 feet.

Two miles east of Gambier, on the south side of the Kokosing valley just north of Arbutus Glen, is another area of kames about one-quarter square mile in extent. The area is within the valley but rises nearly 80 feet above the flood plain of the river, making a terrace-like feature. The surface is strongly undulating rather than with knobs, suggesting kame and kettle topography that has been modified by erosion, the kames being subdued, the kettle holes reduced and breached. Cobbles of resistant rocks are common on the surface. This undulating and irregular surface is very poorly delineated on the Gambier topographic sheet.

VALLEY TRAIN REMNANTS

Outwash gravels must have been laid down in valleys, beyond and within the Illinoian drift region, but they have been so completely removed by later erosion that only a few remnants remain. Only one fairly extensive group of terrace remnants and two isolated remnants have been noted.

Clear Fork Valley.—Remnants of an Illinoian terrace are preserved over a distance of two and one-half miles on the north side of Clear Fork valley at Bellville, Richland County. These remnants are about 60 feet above the continuous lower Wisconsin valley train at Bellville. One small remnant of the higher terrace remains on the south side of the valley.

The remnant of the Illinoian terrace farthest upstream is immediately north of Bellville at an elevation of 1,200 to 1,220 feet, just east of the Wisconsin boundary. One-half mile east of the village, a larger remnant one-third mile long is preserved. It is flat-topped, has an elevation of 1,190 feet, and partly closes a tributary valley from the north. One-quarter mile southeast of the village another small remnant has an elevation of 1,190 feet, and one-half mile farther east, in southern Section 11, a larger remnant about one-half mile long has an elevation of about 1,180 feet. Farther downstream no evidence of Illinoian terrace remnants was noted.

That these remnants of the higher terrace are Illinoian and not a high Wisconsin terrace is shown by several lines of evidence. First, the elevation of the top of the Wisconsin end-moraine at Bellville is 1,180 feet. The well marked valley train extending down valley from it has an altitude of 1,144 feet in Bellville. The remnants of the higher terrace are therefore above the possible reach of Wisconsin waters. Further, the surface of the higher terrace is much more eroded than the surface of the lower terraces. Finally, the mineral grains separated from the soil on top of the higher remnants show the degree of alteration characteristic of Illinoian drift deposits (6).

The remnants represent a valley train that was at least three miles long, and probably much longer, deposited from the Illinoian ice after it had retreated more than eight miles west of its farthest eastward position. These remnants indicate definitely, however, that in the vicinity of Bellville, the valley of Clear Fork was filled, during the waning of the Illinoian ice, to an elevation from 60 to 80 feet higher than the present stream level. All remnants have been completely removed downstream from a point two and one-half miles east of Bellville and Wisconsin glaciation has obliterated any remnants that may have been preserved west of Bellville. It is impossible, therefore, to determine where the valley train headed or how far downstream it extended.

Mohican Valley.—A small bench area about one-half mile long and 100 feet above the Wisconsin terraces exists on the inside of a great bend on the east side of the Mohican River at the Knox-Coshocton county line, one mile southwest of Cavallo. It extends from central eastern Section 20, Union Township, Knox County, eastward into Tiverton Township, Coshocton County, and is crossed by the road along the east side of the Mohican valley. The elevation of this bench is a little over 1,000 feet and the elevation of the Wisconsin terrace below is a little over 900 feet. There are no good exposures of the material, but cobbles are prominent on the surface. These cobbles are more weathered than those of the Wisconsin terrace below. This bench, one mile east of the mapped Illinoian boundary, may be a remnant of local outwash deposited before the present course of the Mohican River was established by the meltwater from the ice.

A small, ridge-like remnant of Illinoian outwash is present in the Walhonding valley, three-fourths mile east of the Mohican River, just northwest of Walhonding village. This remnant is one-quarter mile long and one-eighth mile wide. Its top is considerably dissected, but small, flat-topped areas remain at an elevation of 940 to 960 feet. It is separated from bedrock hills to the north by a small, open valley, one-quarter mile wide. The Illinoian outwash is overlapped to the east and south by an extensive Wisconsin outwash terrace having an elevation of 880 to 900 feet. The Illinoian gravel ridge apparently continues to the northwest, but actually, the ridge to the northwest, above an elevation of 960 feet, is of Mississippian bedrock. The Illinoian gravel is not exposed in any pits, but from surface indications it seems to be medium to coarse-grained, with a few cobbles up to six inches in diameter.

ACKNOWLEDGMENTS

The writer gratefully acknowledges his indebtedness to Professor J. Ernest Carman for many valuable suggestions made during the progress of the field work and during the preparation of most of the manuscript. Discussions with Mr. Wilber Stout and with Dr. W. Storrs Cole were helpful. Thanks are due Professor T. R. Meyers for drafting the map which appears as Fig. 1.

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Nuclear Physics

The rapid development of this branch of physics, together with the great popular interest it has aroused renders a work on this subject a matter of prime importance. The present volume is essentially an English edition of the Italian work of this young co-worker of Fermi (F. Rasetti, Il Nucleo Atomico, Zanichelli, Bologna, 1936).

But any subject which is in a state of rapid transition always lays itself open to the possibility that by the time it is published much of the material that it contains will be obsolete. This criticism applies to this work to a limited extent, although it contains references only three months old. It is valuable to the experimental physicist in its wealth of tables and charts, which to a large degree will probably stand the test of time.

Experimental methods are fully discussed, and in a few cases, brief theoretical discussions are given, but these are, in the main, somewhat sketchy and too advanced for beginning students.

The first half of the book is concerned with an introduction and historical study of the interaction of matter and radiation, including a very fine summary of natural radioactivity. There follows a general study of nuclear structure, including properties derived from other fields of study (principally spectroscopy). The last hundred pages are devoted to artificial disintegration and induced radioactivity and cosmic rays. This is the author's own special field, and is especially well written and up-to-date including mass of nuclei as derived from disintegration processes.

This book is the second volume of the new Prentice-Hall Physics Series edited by E. U. Condon. It is well printed on very fine paper and quite substantially bound.—J. B. GREEN.

Elements of Nuclear Physics, by F. R. Rasetti. xiv+327 pp. New York, Prentice-Hall, Inc., 1936. $4.50.

MORPHOLOGY OF THE FORELIMB OF THE MOLE (SCALOPS AQUATICUS, L.) IN RELATION TO ITS FOSSORIAL HABITS

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INTRODUCTION

The common American mole (*Scalops aquaticus*, Linnaeus) is a completely fossorial animal which spends its entire existence in underground tunnels of its own construction. The fossorial adaptations which enable the mole to lead its subterranean mode of existence have been described, at least in a general way, by numerous authors. The most comprehensive description of the morphology of the mole is the work of Dobson ('82), whose description, however, concerns primarily the European mole (*Talpa europea*) and the star-nosed mole (*Condylura cristata*), although frequent references are made to other species including *Scalops aquaticus*. Slonaker ('20), in addition to summarizing the results of former investigators which, as he pointed out, are more or less fragmentary and scattered promiscuously throughout the literature, also described certain adaptive modifications in the American mole, particularly the osteology of the forelimb and pelvis and correlated these with the animal's habits and environment.

The objectives aimed at in the present paper are threefold, namely: (1) a more detailed description of the osteology of the forelimb of the mole than has heretofore been given; (2) a description of the articulations of the forelimb, including articular surfaces involved, ligaments with their attachments and adaptive modifications, the normal position assumed by each segment of the forelimb and the kinds of movements permitted at the various joints; and (3) a description of the musculature including the arrangement, attachments (origins and insertions), actions and nerve supply of the muscles, with the view to correlating these features with the peculiar functions which the forelimb performs in the process of constructing the underground tunnels.

The mole is especially adapted to a life spent entirely beneath the surface of the ground in burrows where it secures not only shelter but also its food. Its neck appears to be so short that it is almost imperceptible. However, the shortness of the neck is more apparent than real and is due to the fact that the forelimb has shifted forward rather than to an actual shortening of the cervical region of the vertebral column, since this region contains the characteristic number of vertebrae typical of the mammals, namely, seven. The forward shift of the forelimb is the result of the pre-sternum or manubrium having elongated into a keel-shaped bone, to the anterior extremity of which the short clavicles articulate (fig. 1C). As a consequence, therefore, of the forelimbs having shifted forward upon the neck, not only is the latter apparently shortened but the shoulder-joints are brought nearer each other thus causing an apparent shortening of the forelimbs, while preserving at the same time their normal leverage. These are important fossorial adaptations which enable the mole to economize in working room, since a long neck and long, projecting forelimbs would be mechanical disadvantages to a burrowing animal working in close quarters.

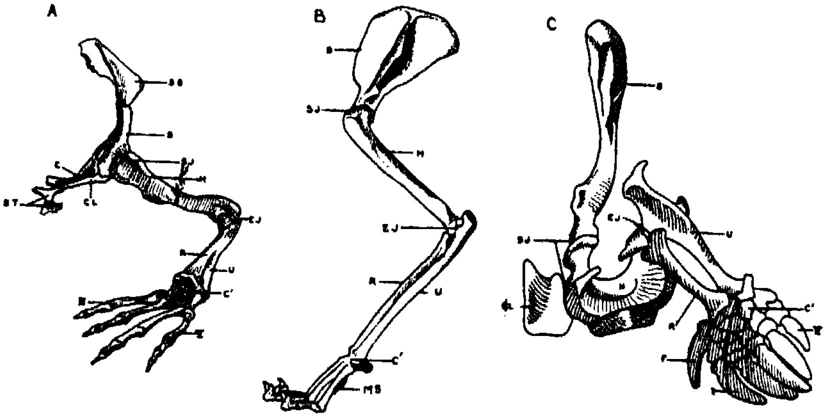


FIG. 1. A—Anterior (cranial) view of articulated forelimb of frog; B—lateral view of articulated forelimb of cat; C—anterior view of articulated forelimb of mole. These illustrations were made with disregard of relative size. (Interpretation of legends is given in list of abbreviations, page 41.)

The bones of the forelimb, especially the clavicle, scapula and humerus, are singularly developed and modified rendering it difficult to homologize certain of their configurations with those of other mammals. They are for the most part quite strong and exhibit prominent processes for the attachment of the powerful muscles which serve to put the forelimbs into action.

The manus is especially modified to form an effective digging mechanism. It is not only strong and broad, but the digits are provided with strongly developed nails sharpened at their tips. Broadening of the manus has been accomplished (1) by a relative increase in the width of the bones of the manus, (2) by the development of an accessory bone, the so-called falciform bone, situated external to the pollex and (3) by the abduction (spreading apart) of the digits which are webbed throughout the greater part of their length. The position of the manus is such as to render it favorable for digging and makes it poorly adapted for progression on a hard supporting surface, as is evidenced by its awkward scraping movements when the animal attempts to scurry to safety when placed on such a surface.

Comparison of the articulated forelimb of the mole when at rest with that of typical tetrapod mammals reveals that the position of its segments has been greatly altered to meet the demands placed upon it. In the more primitive tetrapods, as for example, the amphibians (fig. 1A), the brachium is abducted, that is directed almost horizontally outward at right angles to the longitudinal axis of the body such that the elbow-joint projects laterad; the antibrachium is semi-flexed and semi-pronated and the manus is slightly extended at the wrist-joint so that the palm rests upon the ground. In the typical forelimb of mammals as in the cat for example (fig. 2B), the brachium is swung backward (flexed) and adducted so that the elbow-joint lies close to the side of the body and is directed caudad; the antibrachium is semi-flexed and semi-pronated and the manus is extended at the wrist-joint. As regard the normal position of the tetrapod shoulder-girdle the scapula which, unlike the clavicle, is constant in occurrence, is a flat, triangular bone applied against the lateral aspect of the thorax in an oblique direction, such that its glenoid cavity is directed ventrad and more or less craniad, its superior or vertebral border dorsad and somewhat caudad.

In the forelimb of the mole (fig. 3C) the brachium has assumed a more abducted position than that of the amphibians and in addition has swung forward (extended) in such a manner that the elbow-joint is directed antero-laterad. Moreover the antibrachium is apparently so greatly pronated that the palm of the manus faces postero-laterad. The apparent extreme pronation of the antibrachium is the result of the humerus having undergone considerable medial rotation, as is evident by the spiral course of the nerves to the forelimb (figs. 14, 15), and of the head of the humerus having shifted to its dorsal surface so that its neck and shaft form an angle of about 90°, rather than actual pronation of the antibrachium as is evident from the position of the radius and ulna with respect to each other (fig. 3C).

As a result of the torsion undergone by the humerus its proper lateral border faces antero-mediad and its medial border postero-laterad, while, as a result of extension and abduction, its proximal extremity is directed postero-mediad and its distal extremity antero-laterad. That the radius and ulna have not actually undergone much pronation is evidenced by the fact that they lie parallel with each other and are uncrossed. Moreover, the ulna is situated in a position lateral to that of the radius, a very unusual position due to the torsion of the humerus, while the proper dorsal surface of both radius and ulna faces antero-laterad thus resulting in the radial border of the manus facing postero-laterad and its ulnar border antero-mediad, such that the pollex points ventrad and caudad and the palm faces laterad and caudad. A simulation of the peculiar position assumed by the forelimb of the mole may be gained in the superior extremity of man by performing the following movements: swinging forward and abduction of the brachium at the shoulder-joint to a ninety-degree angle; semiflexion of the antibrachium at the elbow-joint and extreme medial rotation of both the brachium and antibrachium.

Concomitant with the favorable position assumed by the free forelimb of the mole in its burrowing habits are the peculiar morphological modifications and position of the bones of the shoulder-girdle. When the mole is engaged in excavating its burrow considerable lateral pressure is exerted upon the forelimb—hence the importance of a powerful shoulder-girdle to resist the great muscular strain. The clavicle, unlike that of other mammals in which it is present, articulates with the humerus, but not with the scapula. It is so constructed and situated as to resist this lateral pressure and to furnish a strong and stable fulcrum upon which the humeral lever swings.

The scapula exhibits remarkable morphological adaptations in its shape as well as its position. In conformity with the change in position of the humerus as well as its head the shape and position of the scapula have likewise been altered. Thus it has undergone a posterior rotation so that its proper dorsal border is directed caudad, its anterior border dorsad, its posterior border ventrad and the glenoid cavity craniad. Moreover, as a consequence of the humerus having shifted forward due to the forward extension of the manubrium, the scapula has become greatly elongated and has come to lie along the side of the neck and dorsal to the first five or six ribs.

OSTEOLOGY

The **Clavicle** (figs. 1C, 4) is extraordinarily short and somewhat cuboidal in form. Its proximal or medial extremity is marked by an elliptical-shaped concavity which articulates with a reciprocal-shaped convexity on the anterior extremity of the presternum or manubrium. Its distal or lateral extremity presents an oval shaped, concave articular surface for articulation with a similar shaped convex articular surface (clavicular facet) on the greater tuberosity of the humerus (figs. 1C, 5, 6). Its anterior surface is smooth and gives origin to the deltoid muscle (fig. 12). Extending from the anterior to the posterior surface is a foramen which transmits a blood-vessel. On the ventral border is a slight projection, the subclavian tubercle, into which the subclavius muscle (fig. 12) is inserted. Into the posterior aspect of the lateral extremity is inserted the pectoralis minor muscle (fig. 12) and to its superior aspect is attached the acromioclavicular ligament (fig. 15).

The **Scapula** (figs. 1C, 2, 3) is remarkably slender and elongated. Its posterior (original dorsal or vertebral) border is short, rounded and roughened for the attachment of muscles, namely, the trapezius anterior, rhomboids, levator scapulae and serratus (magnus) anterior muscles (fig. 13). Its medial or costal surface presents a slight elongated depression, the subscapular fossa, from which the subscapularis muscle (fig. 15) arises. Its lateral or external surface presents numerous bony configurations; one of these, the spine, into which the trapezius posterior (fig. 13) inserts, is but slightly developed; the supraspinous fossa is narrow, shallow and elongated and furnishes the origin for the supraspinatus muscle (fig. 15); the infraspinous fossa is deeper and marks the point of origin of the infraspinatus muscle (fig. 15). The latter fossa is bounded above and below by ridges, the lower giving rise to the teres minor muscle (fig. 15) and to the long or scapular head of the triceps muscle (figs. 13–15).

A coracoid process is not in evidence. However, the acromion process is well marked and somewhat roughened for the attachment of the acromioclavicular ligament.

The ventral (original posterior) border of the scapula is rounded and gives origin to the teres major muscle (figs. 13–15). The glenoid fossa, which receives the head of the humerus, is shallow and elongated transversely. Near it on the ventral border is a slight projection, the infraglenoid tubercle, from which the biceps brachii muscle (figs. 12, 15) arises.

The **Humerus** (figs. 1C, 5, 6) is most unusual in shape and is characterized by its shortness, the great development of its processes for muscular attachments and by the presence of an articular surface (clavicular facet) for articulation with the clavicle. The head is elongated transversely and projects posteriorly. The neck, into which the supraspinatus muscle inserts, forms an angle with the shaft of about 90°.

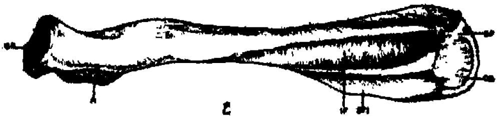
The proximal extremity is marked by the peculiarly shaped tuberosities. The greater (external) tuberosity presents a large oval shaped articular facet (clavicular facet) for the lateral extremity of the clavicle and a sharp spinous process which projects distally. From the posterior aspect of the former arises the deep portion of the external head of the triceps (fig. 14) and into it is inserted the infraspinatus muscle. From the spinous process arises the superficial portion of the external head of the triceps and into it inserts the teres minor muscle (fig. 15). The greater tuberosity overhangs a deep fossa which extends upward under the clavicular facet and is continuous on the lateral border with a spiral groove. This fossa and groove, which curves forward to the ventral surface, give origin to the brachialis muscle (figs. 12, 15).

The lesser (internal) tuberosity consists of two laminae of bone which fuse to form the so-called bicipital ridge and the intertubercular (bicipital) groove. Into the ridge are inserted the subscapularis muscle (fig. 15) and the posterior superficial and deep portions of the pectoralis major muscle (figs. 12, 15). The groove is peculiar in that it is transformed into a closed canal for the passage of the long, slender tendon of origin of the biceps muscle (fig. 15). Distal to these laminae is a notch, which separates them from a crest-like process (L3) into which is inserted the conjoined tendon of the latissimus dorsi and teres major muscles (figs. 12, 15). The tendon of origin of the biceps passes through this notch to gain the ventral surface of the humerus.

The ventral surface presents proximally a large, smooth triangular surface bounded externally by the deltoid tuberosity and internally by the pectoral ridge. Into the former inserts the deltoid muscle and into the latter are inserted the anterior superficial and deep portions of the pectoralis major muscle (figs. 12, 15). The dorsal surface is marked by a pronounced, obliquely situated, groove from which the internal head of the triceps muscle (figs. 12, 13, 15) arises.

The distal extremity presents a number of processes, two of which are articular for the bones of the antibrachium, while the others serve for muscular attachments. The lateral epicondyle consists of a sharp spinous process which gives origin to the anconeus externus muscle (fig. 14) and the dorsal or extensor group of muscles of the antibrachium (figs, 13, 15). Just internal to this is the smooth, oval shaped capitulum for articulation with the proximal extremity of the radius and above the capitulum is a slight depression, the radial fossa, for the reception of the margin of the sigmoid cavity on the proximal end of the radius during extreme flexion of the elbow-joint.

The medial epicondyle is marked by a spinous process proximally and a facet-like process distally. From the former arise the anconeus internus, pronator teres and palmaris longus muscles, while to the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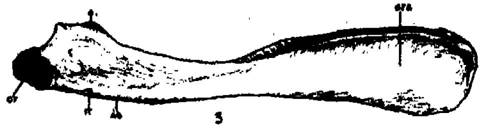
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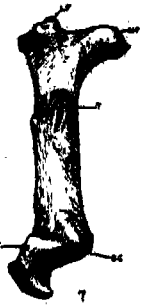
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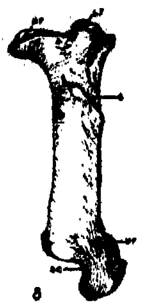
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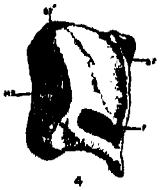
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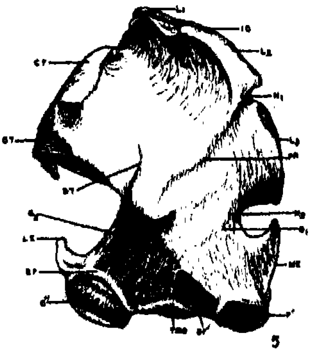
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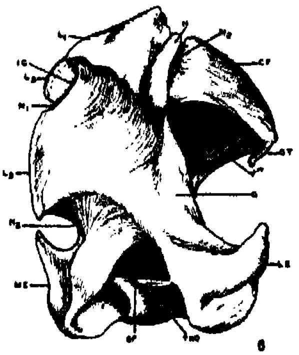
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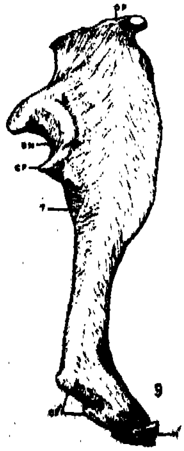
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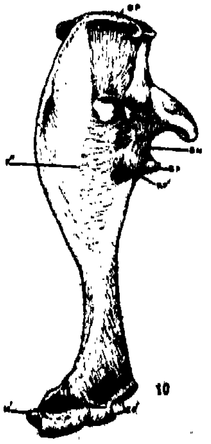
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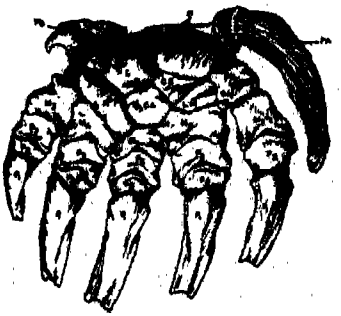
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FIG. 2. Lateral aspect of right scapula of mole.
FIG. 3. Medial aspect of right scapula of mole.
FIG. 4. Anterior (cranial) aspect of right clavicle of mole.
FIG. 5. Ventral (original anterior) aspect of right humerus of mole.
FIG. 6. Dorsal (original posterior) aspect of right humerus of mole.
FIG. 7. Ulnar (original medial) aspect of right radius of mole.
FIG. 8. Medial (original lateral) aspect of right radius of mole.
FIG. 9. Lateral (original medial) aspect of right ulna of mole.
FIG. 10. Medial or radial (original lateral) aspect of right ulna of mole.
FIG. 11. Dorsum of right articulated manus of mole.

(Interpretation of legends is given in list of abbreviations, page 41.)

latter is attached the tendinous flexor digitorum profundus (fig. 14). Adjacent to the medial epicondyle on the ventral surface are the supracondylar foramen, which transmits the median nerve, and a slight coronoid fossa for the reception of the coronoid process of the ulna (fig. 10) during extreme flexion of the elbow-joint, while on the dorsal surface is the deep olecranon fossa for the reception of the posterior margin of the semilunar notch of the ulna during extreme extension of the elbow-joint.

The **Radius** (figs. 1C, 7, 8) is also greatly modified. Thus its proximal extremity presents a sigmoid cavity for articulation with the capitulum of the humerus rather than a circular disc or head as in most higher forms. On its medial aspect is a small articular facet for articulation with a corresponding facet on the adjacent margin of the proximal extremity of the ulna. The medial surface of the shaft is roughened, forming what may be termed the bicipital tuberosity for the insertion of the biceps brachii muscle (figs. 12, 15), near which is the point of insertion of the pronator teres muscle (fig. 14). The lateral surface presents an obliquely directed groove through which the tendon of the extensor ossi metacarpi muscle (fig. 15) glides. The distal extremity is greatly expanded from lateral to medial and bears two articular surfaces, a lateral one for articulation with the navicular (scaphoid) bone and a medial one for articulation with the lunate (semilunar) bone. Little or no articulation occurs between this extremity of the radius and that of the ulna.

The **Ulna** (figs. 1C, 9, 10) exhibits still greater fossorial adaptations. Its proximal extremity is marked by a greatly pronounced olecranon process which is expanded at its free end and is keeled throughout its length, as a result of which leverage of the extensor muscles of the elbow-joint is greatly increased. Into this process are inserted the anconeus externus and internus (figs. 14, 15) and the triceps (figs. 14, 15) muscles, while it serves for the point of origin of the flexor (fig. 14) and extensor (fig. 13) carpi ulnares, the flexor digitorum sublimis (fig. 14), the extensor pollicis et indicis (fig. 15) and the extensor ossi metacarpi (fig. 15) muscles. The semilunar notch is so deep and narrow that it almost approximates a hollow cylindrical articular surface which tends to increase the stability of the elbow-joint. It is bounded proximally by a hook-like process of the olecranon and distally by the coronoid process. Just distal to the latter on the volar (anterior) surface is a roughened area, the ulnar tuberosity, into which the brachialis muscle (fig. 15) is inserted. As mentioned above, on the lateral margin of the semilunar notch is a small articular facet for articulation with a corresponding one on the medial margin of the sigmoid cavity of the radius. The distal extremity presents laterally a notched articular surface, which articulates with the triquetral (cuneiform) bone, and medially a hook-like articular surface, which articulates with the pisiform bone.

The **Manus** (figs. 1C, 11) is composed of the typical divisions, namely, the carpus, metacarpus and digits. The carpus consists of two rows of bones, a proximal row containing the navicular (scaphoid), lunate (semilunar), triquetral (cuneiform) and pisiform, and a distal row containing the greater multangular (trapezium), lesser multangular (trapezoid), the central (centrale or intermedium), the capitate (os magnum) and hamate (unciform). The palmar aspect of the carpus is smooth and is bounded laterally by a ridge on the navicular bone and medially by the pisiform bone, thus forming a somewhat shallow groove for the passage of the tendons of the volar or flexor group of antibrachial muscles.

The metacarpal bones are five in number and quite short. They are somewhat wedge-shaped with their palmar surfaces reduced to narrow transverse crests in which are grooves for the tendons of the flexor digitorum profundus muscle. The phalanges are short, broad and flattened, with the typical number present. The distal or terminal phalanges are bifid and provided with long, broad nails sharpened at their tips. The falciform bone lies to the lateral side of the pollex and is attached proximally to the navicular bone while its distal free extremity extends to the base of the proximal phalanx of the pollex.

ARTICULATIONS

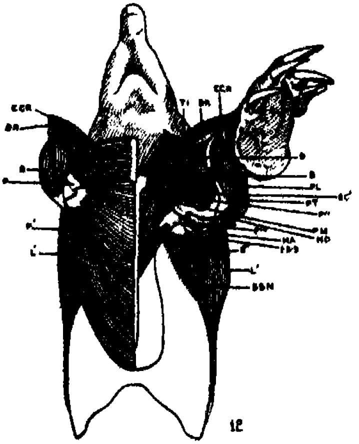
The **Sternoclavicular-joint** is surrounded by an articular capsule which is reinforced dorsally and ventrally by accessory ligaments. An articular disc is not present as in man. The movements permitted at this joint are protraction (swinging forward) and retraction (swinging backward) of the clavicle.

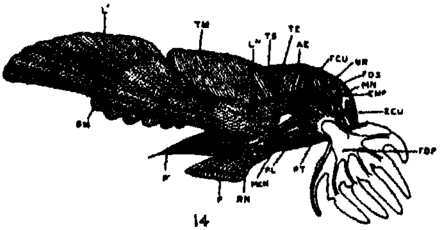
The **Shoulder-joint** (fig. 3C) is a double one, being composed of a humero-scapular and a humero-clavicular element. Since the humerus typically articulates only with the scapular element of the shoulder-girdle, it is apparent that the significance of this double articulation in the mole is that it adds stability and serves to produce a firm support for the humerus to swing upon as a lever during the digging movements. The clavicle of the mole therefore does not serve as a prop to support the scapula as in man, but rather as a fulcrum on which the humerus swings.

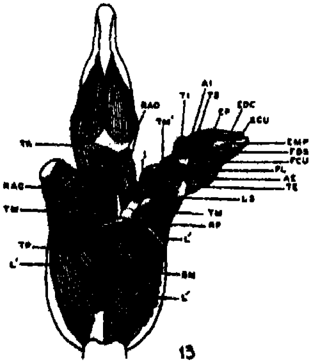
The ligaments involved in this articulation are two articular capsules, one for each part of the joint. These are reinforced dorsally and ventrally by accessory bands of fibers. In addition the strong acromioclavicular ligament (fig. 15) adds further strength and security. It is attached to the acromion of the scapula and to the dorsal aspect of the lateral end of the clavicle. The attachments and size of this ligament would seem to indicate that it serves to brace the proximal end of the scapula against the lateral end of the clavicle and, therefore, compensates for the lack of an articulation between these bones.

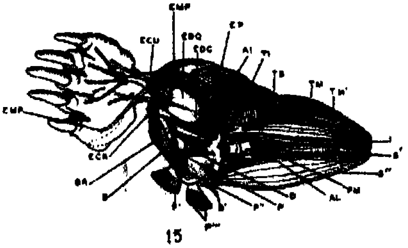
Due to the nature of the articular surfaces composing the shoulder-joint it is probable that the movements permitted at the humero-clavicular portion are swinging forward (extension) swinging backward (flexion), elevation sideward (abduction) and depression to the side (adduction), whereas it is possible that only abduction and adduction occur at the humero-scapular portion. It is doubtful whether rotation of the humerus takes place at either of these points, since the nature of the articular surfaces and arrangement of the ligaments, especially the acromioclavicular, would seem to render this movement impossible.

The **Elbow-joint** (fig. 3C) is likewise a double articulation, consisting of humero-ulnar and humero-radial elements. As a result of the nature of the articular surfaces involved great strength and security are obtained here. In addition to the articular capsule, with which each element is provided, accessory ligaments are present. These extend from the margin of the sigmoid cavity of the radius to the lateral epicondyle and adjacent margin of the semilunar notch of the ulna and from the latter to the medial epicondyle. The movements which occur are limited to flexion and extension.









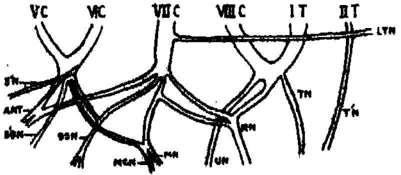


Fig. 12. Ventral aspect of muscles of forelimb of mole.
Fig. 13. Dorsal aspect of muscles of forelimb of mole.
Fig. 14. Lateral aspect of muscles of right forelimb of mole.
Fig. 15. Medial aspects of muscles of right forelimb of mole.
Fig. 16. Diagram of left brachial plexus of mole, showing the origin of only the nerves to the muscles of the forelimb.

(Interpretation of legends is given in list of abbreviations, page 41.)

Although the proximal extremities of the radius and ulna articulate, forming what may be termed a superior radio-ulnar articulation, it is doubtful whether any pronation or supination occur here.

The **Wrist-joint** (fig. 3C) is also a double articulation. It consists of two facets on the distal extremity of the radius, which articulate with the navicular and lunate bones, and articular surfaces on the distal extremity of the ulna, which articulate with the triquetral and pisiform bones. According to Dobson (loc. cit., p. 164) the pisiform bone does not enter into the wrist-joint. However, in Scalops aquaticus this is a well defined articulation and the articular surfaces are of such a nature as to form somewhat of an interlocking device thus adding security to the joint, and permits only flexion and extension. It is provided with an articular capsule which is reinforced by means of short, strong ligaments.

An inferior radio-ulnar articulation does not occur, although ligaments connect the distal extremities of the radius and ulna.

In the remaining articulations of the manus flexion and extension occur freely, the digits maintaining a position of abduction, that is spread apart. Moreover, the normal position of the digits when the mole is at rest is extension rather than slight flexion as in man thus giving the manus its shovel-like appearance. The base of the falciform bone is held firmly against the lateral side of the navicular bone by means of short, strong ligaments. It is attached throughout most of its length to the side of the pollex by a fold of skin.

MUSCULATURE

The origin, insertion and nerve supply of the muscles of the forelimb were observed by means of dissection, whereas their actions were determined by applying the principles of leverage, that is, by noting their points of attachment on the articulated limb, by pulling upon the dissected muscles and observing the resulting movements. Observations were made on the movements of the living animal, although these yielded unsatisfactory results as regard primary muscle action. However, the fundamental movements of the various segments of the forelimb during the digging process were thereby ascertained. Naturally, the question arises as to the homology of these muscles with those of higher mammals. Notwithstanding the difficulties encountered due to the numerous modifications and morphological adaptations exhibited by the majority of these muscles, this was, for the most part, readily determined by employing the criteria of nerve supply and morphology, including points of attachment. However, in a few instances, notably the pectoralis minor and subclavius muscles, their homology is questionable and the writer may be in error in employing these names. As regard the subclavius Dobson observed and described it as such for the star-nosed mole, whereas he made no mention of the muscle described in this paper as the pectoralis minor but applied this name to the posterior deep portion of the pectoralis major, with which it is generally conceded to be homologous.

In addition to the proper appendicular muscles of the fore-limb there are two cutaneous muscles attached to the humerus, namely, the humero-dorsalis and humero-abdominalis. These are portions of the cutaneous maximum or panniculus carnosus which serves primarily to move the integument. However, since these two muscles are attached to the humerus (origin) and to the skin of the back and abdomen (insertion) their action may be reversible, that is they may serve to move the humerus.

The **Humero-dorsalis** (fig. 12) arises from the shaft of the humerus under cover of the biceps brachii muscle and inserts into the skin on the sides of the back. It may serve indirectly to flex the humerus, that is, draw it backward.

The **Humero-abdominalis** (fig. 12) arises from the bicipital ridge of the humerus under cover of the insertion of the posterior superficial pectoralis major and inserts into the skin on the sides of the abdomen. It may likewise serve to flex the humerus.

The **Pectoralis major** (figs. 12, 14, 15) is a large, complex muscle which extends from the ventral aspect of the thorax to the humerus. It is divisible into four parts, two of which are superficial and two deep. The anterior superficial pectoralis (pars clavicularis of man) (P) arises from the anterior end of the manubrium and from a raphè craniad to it and inserts into the pectoral ridge of the humerus. This raphè forms a common tendon of origin for both anterior superficial pectorals thus providing a continuous band stretching across between both forelimbs and serving to hold them in position. The posterior superficial pectoralis (pars sternocostalis of man) (P′) takes origin from the entire length of the sternum and is inserted into the bicipital ridge of the humerus. The anterior deep pectoralis (pars prescapularis; pectoralis parvus) (P″) arises from the anterior surface of the clavicle and inserts into the pectoral ridge of the humerus. The posterior deep pectoralis (pectoralis minor of man) (P′ ″) arises from the manubrium and costal cartilages and inserts into the bicipital ridge of the humerus. The action of the pectoralis major as a whole is to adduct the humerus. Its separate divisions when acting as functional units perform the following movements: the anterior superficial and deep portions pull the humerus forward while the posterior superficial and deep portions pull it backward.

The **Subclavius** muscle (fig. 12) is situated deep to the pectoralis major where it arises from the side of the manubrium and the first few costal cartilages. It passes forward to be inserted into the subclavian tubercle of the clavicle. It retracts the clavicle, that is, pulls it backward, and like its homologue (?) in man subserves the function of bracing the clavicle against the manubrium.

The **Pectoralis minor** muscle (figs. 12, 15) lies deep to the subclavius. It takes origin from the manubrium and is inserted into the posterior aspect of the lateral end of the clavicle, the acromioclavicular ligament and the acromion of the scapula. It retracts the shoulder-girdle. As mentioned previously the homology of this muscle is questionable. The writer ventures the suggestion that it may represent a muscle occasionally appearing in man and described in Quain's Anatomy

('23, p. 104) as the sterno- or chondroscapularis (subclavius posticus), which is said to arise from the manubrium and first costal cartilage and after passing behind the clavicle and normal subclavius to be inserted into the superior border of the scapula.

The **Trapezius** muscle (fig. 13) consists of two portions, anterior and posterior. The anterior trapezius (cranial part of human trapezius) arises from the occipital bone and inserts into the posterior border of the scapula. The posterior trapezius (caudal part of human trapezius) arise from the pelvic and sacral bones and inserts into the spine of the scapula. The *anterior trapezius serves to pull the scapula forward* and the posterior trapezius to draw it backward.

The **Rhomboideus** muscle (fig. 13) is also divisible into two portions, namely, anterior and posterior. The rhomboideus anterior is in turn divisible into cervical and occipital portions. The cervical portion (RAC) arises from the ligamentum nuchae, which is here ossified, and inserts into the posterior border of the scapula. It serves to draw the scapula forward (protract) and medial (adduct). The occipital portion lies partly under cover of the anterior trapezius. It takes origin from the occipital bone and is inserted into the ligamentum nuchae. It acts as a brace for the ligamentum nuchae thereby giving it support for the action of the cervical portion. The rhomboideus posterior arises from a common tendon, in conjunction with its fellow of the opposite side, which is attached to the last cervical and first thoracic vertebrae. Insertion is into the posterior border of the scapula and the action is to adduct the scapula. Moreover, with its fellow of the opposite side it serves as a ligamentous band which tends to hold the scapulae in close proximity. Dobson claims (loc. cit., p. 166) that the occipital portion of the rhomboideus anterior is "inserted into the postero-internal margin of the scapula," thus differing from the observations made by the writer.

The **Levator scapulae** muscle (fig. 13) is situated on the lateral aspect of the neck where it arises from the sides of the cervical vertebrae and inserts into the posterior border of the scapula. It protracts the scapula.

The **Serratus anterior** (magnus) muscle (figs. 13, 14) lies on the lateral aspect of the thorax where it arises by digitations from the first 8 or 9 ribs. It passes between the medial surface of the scapula and the ribs to be inserted into the posterior border of the scapula. Its chief action is to abduct the scapula, that is, pull it laterad.

The **Latissimus dorsi** muscle (figs. 12–14) is a large fan-shaped muscle situated on the side of the trunk. It takes origin from the spinous processes of the last few thoracic and all of the lumbar vetrebrae and from the dorsal surface of the sacrum. Its tendon fuses with that of the teres major muscle forming a common tendon which is inserted into the *distal process (L3)* on the posterior (*medial*) border of the humerus. The action of these muscles is to flex and abduct the humerus.

The **Tensor fasciae antibrachii** (epitrochlearis) (fig. 14) is a quadrilateral-shaped muscle arising from the tendon of the latissimus dorsi and inserting into the antibrachial fascia and olecranon process. It serves to extend the elbow-joint and to make the fascia tense.

The **Teres major** muscle (figs. 13–15) forms a pronounced muscular mass situated on the inferolateral aspect of the scapula. It arises from the entire length of the ventral border of the scapula and inserts along with the latissimus dorsi as mentioned above.

The **Teres minor** muscle (figs. 13, 15) is a long spindle-shaped muscle situated on the lateral aspect of the scapula. It is separated from the teres major muscle by means of the long head of the triceps brachii and its tendon passes to the lateral side of the acromion and acromioclavicular ligament. It arises from the ridge which forms the lower boundary of the infraspinous fossa of the scapula and inserts into the spinous process on the greater tuberosity of the humerus. It is a weak flexor and abductor of the humerus. According to Dobson (loc. cit., p. 168) this muscle "appears to be absent."

The **Infraspinatus** muscle (figs. 13, 15) is a small spindle-shaped muscle located deep on the teres minor with which it is blended. Its origin is from the infraspinous fossa of the scapula and its insertion is into the posterior margin of the clavicular facet of the humerus. It assists in flexing and abducting the humerus.

The **Supraspinatus** muscle (fig. 15) is a long fusiform muscle which arises, as its name implies, from the supraspinous fossa and inserts into the dorso-medial aspect of the neck of the humerus. Its tendon passes medial to the acromion and acromioclavicular ligament. The action of this muscle is similar to that of the infraspinatus.

The **Subscapularis** muscle (fig. 15) occupies the entire subscapular fossa of the scapula from which it takes origin. The insertion is into the bicipital ridge of the humerus. The angle of pull is such that it must be considered a flexor and abductor of the humerus.

The **Deltoid** (figs. 12, 15) is a thin, quadrilateral-shaped muscle lying under cover of the anterior superficial portion of the pectoralis major muscle. It lies parallel with the anterior deep portion of the pectoralis major with which it is blended. Its origin is from the anterior surface of the clavicle and its insertion is into the deltoid ridge of the humerus. It serves to extend the humerus and possibly to adduct it.

The **Triceps brachii** (figs. 12–15) forms a large muscular mass on the posterior aspect of the humerus. It consists of three heads, namely, a scapular (long) head, an external head and an internal head. The scapular head (Ts) arises from the ridge forming the lower boundary of the infraspinous fossa, where it separates the teres major and minor muscles. This point of origin differs from that in typical mammals in which it arises from the ingraglenoid tubercle along the axillary border and is explained on the basis of the shift in position of the humerus. The external (lateral) head (TE) is divisible into two parts, a superficial which arises from the spinous process on the greater tuberosity of the humerus and a deep which arises from the posterior margin of the articular (clavicular) facet on the greater tuberosity. The internal (medial) head (TI) arises from the groove on the posterior aspect of the shaft of the humerus. The tendon formed by the union of these heads is inserted into the expanded extremity of the olecranon process of the ulna. The action of this muscle as a whole is to extend the fore-arm at the elbow-joint while the scapular head may assist indirectly in flexing the humerus at the shoulder-joint.

The **Biceps brachii** (figs. 12, 15) is a thick, fusiform muscle lying on the anterior surface of the humerus. Its tendon of origin is strong, long and rounded (B′) and is attached to the infraglenoid tubercle of the scapula. This point of attachment presents a peculiar modification since in higher mammals the tendon of origin is attached to the opposite side of the glenoid fossa, that is, to the supraglenoid tubercle. Moreover, as mentioned above, the infraglenoid tubercle in higher forms marks the point of origin of the long head of the triceps. In conformity with the change of position of the humerus, that is, from the adducted position to the abducted and medially rotated one, the point of origin of this muscle as well as that of the long head of the triceps has shifted in the mole. The tendon of the biceps undergoes a rather tortuous course, passing at first ventrally to gain entrance into the closed bicipital canal of the humerus, from which it emerges to curve forward through the notch separating the ridges on the medial border of the humerus. The muscle is inserted into the roughened area (bicipital tuberosity) on the medial surface of the shaft of the radius. As in typical mammals this muscle serves primarily to flex the antibrachium at the elbow-joint. However, unlike that in most mammals, it does not supinate this region, since little or no supination occurs. Moreover, in view of the course of its tendon of origin and of its direction of pull, it may possibly adduct the brachium.

The **Brachialis** (figs. 12, 15) forms a rounded, muscular mass which occupies the fossa under the greater tuberosity and the spiral groove on the antero-lateral surface of the humerus. Its tendon of insertion is attached to the tuberosity of the ulna. It assists the biceps in flexing the antibrachium at the elbow-joint.

The **Anconeus externus** (figs. 13, 14) is a triangular-shaped muscle which arises from the spinous process on the lateral epicondyle and tendon of the teres major muscle. It inserts into the lateral surface of the olecranon process of the ulna and assists the triceps in extending the antibrachium at the elbow-joint.

The **Anconeus internus** (figs. 13, 15) is situated on the medial aspect of the humerus where it arises from the spinous process on the medial epicondyle and inserts into the expanded tip of the olecranon process. It also assists in extending the antibrachium.

The **Pronator teres** (figs. 12, 14) is situated on the volar surface of the fore-arm between the biceps and palmaris longus. It arises from the anterior aspect of the medial epicondyle of the humerus between the styloid process and the facet, and is inserted into the medial surface of the shaft of the radius. Its chief action is to assist in flexing the antibrachium. It is doubtful whether it produces any pronation of the fore-arm, since the nature of the articulation tends to limit such a movement.

The **Palmaris longus** (figs. 12–14) forms a thick muscular mass on the volar surface of the antibrachium where it lies parallel with and medial to the pronator teres. It arises from the styloid process of the medial epicondyle of the humerus. It gives off two tendons, one of which passes lateralward to be inserted into the palmar surface of the falciform bone, the other passes medialward to be inserted into the ulnar side of the distal phalanx of the fifth digit. It serves primarily to increase the width of the manus by abducting the falciform bone and the fifth digit, although it also acts to flex the manus and the antibrachium.

The **Flexor carpi ulnaris** (figs. 13, 14) lies medial to the palmaris longus on the volar surface of the antibrachium. It arises by fleshy fibers from the medial surface of the keeled olecranon process and inserts into the pisiform bone. It assists in flexing the manus at the wrist-joint.

The **Flexor digitorum sublimis** (figs. 13, 14) lies deep to but is larger than the flexor carpi ulnaris. It takes origin on the medial surface of the olecranon process and the shaft of the ulna. Its tendon passes laterally under that of the flexor carpi ulnaris to gain the palmar aspect of the manus where it intimately blends with the underlying tendon of the flexor digitorum profundus. It assists in flexing the manus and may indirectly assist the latter muscle in flexing the digits.

The **Flexor digitorum profundus** (fig. 14) presents a very interesting fossorial adaptation. It consists of two heads of origin, one of which is muscular and the other tendinous. Its muscular origin is from the anterior border of the shaft of the ulna, while its tendinous origin is from the facet on the medial epicondyle of the humerus. The tendinous portion is quite pronounced forming a wide, strong band which is joined obliquely by the muscular portion. It enters the palm of the manus by passing through the smooth groove formed by the proximal row of the carpal bones. Within the palm it divides into five tendinous slips which insert into the terminal phalanges of the digits. The action of this muscle is threefold, namely, to flex the manus and the digits, and to exert a ligamentous action on the manus and digits by checking over-extension, thus increasing the efficiency of the shovel-like action of the manus.

The **Extensor carpi radialis** (figs. 12, 15) is a small, fusiform muscle lying on the radial side of the dorsal surface of the antibrachium. It arises from the spinous process of the lateral epicondyle of the humerus and inserts into the bases of the second and third metacarpal bones. Its tendon is crossed by that of the extensor ossis metacarpi pollicis and is held down firmly as it passes over the carpus by a ligamentous band or annular ligament. It assists in extending the manus at the wrist-joint.

The **Extensor digitorum communis** (figs. 13, 15) forms a prominent muscular mass along the middle of the dorsal surface of the antibrachium. It arises from the spinous process of the lateral epicondyle of the humerus. It breaks up into tendons which, after passing through an annular ligament, insert into the terminal phalanges of the lateral four digits. It extends the manus and digits.

The **Extensor (minimi) digiti quinti proprius** (fig. 15) is a small fusiform muscle lying on the ulnar side of the extensor digitorum communis with which it is intimately fused. It arises from the spinous process of the lateral epicondyle of the humerus and inserts by means of a slender tendon into the terminal phalanx of the fifth digit. It serves to extend the fifth digit and assists in extending the manus.

The **Extensor carpi ulnaris** (figs. 13–15) is a fusiform-shaped muscle lying on the ulnar side of the extensor digiti quinti. It arises by two heads, one from the lateral epicondyle of the humerus and one from the expanded tip of the olecranon process. Its tendon of insertion is attached to the distal extremity of the ulna, from which it passes forward and divides into two tendons which are attached to the bases of the fourth and fifth metacarpals. It assists in extending the manus at the wrist-joint.

The **Extensor pollicis et indicis** (figs. 13, 15) is a triangular-shaped muscle situated on the ulnar side of the extensor carpi ulnaris where it arises from the tip of the olecranon process. Its small, thin tendon passes obliquely under that of the extensor digitorum communis through the annular ligament to the dorsal surface of the hand where it divides into two tendons which insert into the terminal phalanges of the pollex and index finger, respectively. It serves, as its name implies, to extend the pollex and index finger (2nd. digit) and also indirectly the manus.

The **Extensor ossis metacarpi pollicis** (extensor pollicis brevis) (figs. 13–15) lies deep to the extensor pollicis et indicis on the ulnar side of the dorsal surface of the antibrachium. It arises by two heads, one from the lateral surface of the keeled olecranon process and shaft of the ulna, the other from the lateral surface of the radius. Its tendon passes obliquely laterad through a groove on the shaft of the radius under cover of the tendons of the extensor digitorum communis, thence it passes over the tendon of the extensor carpi radialis to the radial side of the base of the first metacarpal. It extends the manus at the wrist-joint.

No intrinsic muscles were discernible in the manus.

Nerve Supply—The muscles of the forelimb are innervated for the most part by nerves which branch from the brachial plexus, a diagram of which is shown in figure 16. The pectoralis major and minor muscles are supplied by the anterior thoracic nerves, which arise from the 5th, 6th and 7th cervical nerves and pass ventrally to enter the muscles. The humero-dorsalis and humero-abdominalis muscles are supplied by branches from the 1st and 2nd thoracic nerves which pass laterad and form a plexus on the deep surface of the muscles. The nerve which supplies the subclavius muscle arises from the 5th and 6th cervical nerves. It passes directly craniad along the supero-lateral surface of the manubrium to the posterior surface of the clavicle where it terminates in the muscle.

The levator scapulae and rhomboideus muscles receive their nerve supply from branches of the cervical plexus. These branches ascend along the cranial border of the levator scapulae, giving off twigs in their ascent, to terminate in the rhomboideus muscles. The levator scapulae is, in addition, supplied by a branch from the long (posterior) thoracic nerve, which arises from the 7th cervical nerve. It passes caudad on the surface of the seratus anterior muscle which it also supplies. The trapezius is likewise innervated by some twigs from the cervical plexus and by the spinal accessory nerve. The latter nerve courses along the lateral margin of the trapezius anterior muscle, giving off twigs, and terminating in the trapezius posterior.

The supraspinatus, infraspinatus, teres minor and deltoid muscles are supplied by a nerve which arises from the 5th and 6th cervical nerves. This nerve probably represents the combined suprascapular and axillary nerves common to mammals. It extends laterad from its point of origin and enters the supraspinatus muscle where it gives off branches to the other muscles.

The subscapularis, latissimus dorsi and teres major muscles are supplied by the subscapular nerves (fig. 12) which arise from the 5th, 6th and 7th cervical nerves.

The biceps brachi and brachialis muscles receive their supply through the musculocutaneous nerve which takes origin from the 5th, 6th and 7th cervical nerves. This nerve is the most anterior of the four nerves (fig. 14) which curve round the lateral aspect of the axilla.

The tensor fasciae antibrachii, anconeus internus and externus, triceps brachii and the extensor muscles of the antibrachium are supplied by the radial nerve which arises from the 7th and 8th cervical and 1st thoracic nerves. It curves round the lateral boundary of the axilla where it is the most posteriorly situated of the four nerves observed at this point (fig. 14). It enters the brachium just posterior to the anconeus externus and after giving off branches to the extensor group of muscles of the brachium enters the antibrachium by curving round the spinous process of the lateral epicondyle.

The flexor group of muscles of the antibrachium are supplied by the median and ulnar nerves. The median nerve arises from the 5th, 6th and 7th cervical nerves, passes laterad just posterior to the musculocutaneous nerve (fig. 14), passes into the brachium deep to the anconeus externus and enters the antibrachium through the supracondylar foramen. It supplies all the volar antibrachial muscles with the exception of the flexor carpi ulnaris. The ulnar nerve arises from the 8th cervical and 1st thoracic nerves, runs parallel with and between the median nerve anteriorly and the radial nerve posteriorly (fig. 14) and enters the antibrachium, by curving round the spinous process of the medial epicondyle, where it supplies the flexor carpi ulnaris and sends some twigs into the flexor digitorum profundus.

DISCUSSION AND SUMMARY

The most striking morphological adaptations exhibited by the bones of the forelimb of the mole may be summarized as follows: the cuboidal form of the clavicle and its articulation with the humerus rather than with the scapula; the elongation of the scapula; the broadening of the humerus, the pronounced development of its processes for muscular attachments, the closure of its intertubercular groove, the presence of a clavicular facet and the shift in position of the head to its dorsal surface; the presence of a sigmoid articular surface on the proximal end of the radius; the elongation and expansion of the olecranon process, the deep semilunar notch and carpel articulation of the ulna; the increased relative width of the bones of the manus; the presence of an accessory falciform bone and the development of strong, nail-like claws.

As regard the position of the bones in the articulated forelimb the most salient features are as follows: the craniad shift in position of the shoulder-girdle due to the elongation of the manubrium; the rotation of the scapula resulting in its original dorsal border facing caudad and its glenoid cavity directed craniad; the abduction of the humerus to a ninety-degree angle accompanied by extreme medial rotation resulting in its original lateral border facing craniad and its distal end projecting antero-laterad; the lack of a distal radio-ulnar articulation; the uncrossed position of the radius and ulna with the radius situated antero-mediad and the ulna postero-laterad so that their original volar surfaces face postero-mediad and the palm of the manus postero-laterad, with the pollex directed caudad and the fifth digit craniad.

The chief fossorial adaptations manifested by the muscles of the forelimb of the mole are such features as the following: the great development of certain muscles, as for example the teres major, latissimus dorsi, pectoralis major and palmaris longus, which serve to put the limb in its peculiar position as well as into action; the absence of certain muscles normally present in the mammalian forelimb, as for example, the mastoideohumeralis (brachiocephalicus), scapulohumeralis posticus (capsularis), coracobrachialis, brachioradialis, supinator, pronator quadratus, abductor pollicis longus, flexor carpi radialis and the intrinsic muscles of the manus; the acquisition of new points of origin of the biceps brachii and the long head of the triceps brachii and the change in action of certain muscles, as for example, the occipital portion of the rhomboideus anterior, the teres major and deltoid due to alteration of position of the forelimb.

It is evident that the normal position of the brachium of the mole, that is abduction accompanied by extreme medial rotation, is maintained by active muscular contraction. The muscles acting on the humerus to produce abduction and medial rotation are the latissimus dorsi, teres major and minor, infraspinatus, supraspinatus and subscapularis, assisted by the pectoralis major in rotation.

During the excavation of the underground tunnels the forelimb of the mole alternately swings backward and forward with great strength and rapidity, much in the same fashion as the swimming movements of man. The backward movement is, of course, the more powerful since it supplies the impetus resulting in pushing the earth aside, whereas, the forward swing serves to place the limb in a favorable position for the backward thrust. During the forward swing the brachium, antibrachium, manus and digits are extended and in the backward thrust these parts are powerfully flexed. Concurrent with these fundamental movements of the free forelimb are complimentary movements of the shoulder-girdle, that is forward (protraction) and backward (retraction), thus serving to impart added impetus to the movements of the free limb and to maintain the articular surfaces of the shoulder-joint in apposition.

The muscles acting on the various parts of the forelimb in the production of these movements are summarized as follows: extension (swinging forward) of the brachium at the shoulder-joint is produced by the anterior (superficial and deep) portion of the pectoralis major and the deltoid; flexion (swinging backward) of the brachium by the latissimus dorsi, infraspinatus, supraspinatus, teres major and minor, subscapularis, long head of the triceps brachii and the posterior (superficial and deep) portion of the pectoralis major; flexion of the antibrachium at the elbow-joint by the biceps brachii, brachialis and the volar antibrachial muscles, which arise from the medial (internal) epicondyle of the humerus (namely, pronator teres and palmaris longus); extension of the antibrachium by the triceps brachii, anconeus externus and internus and the dorsal antibrachial muscles, which arise from the lateral epicondyle of the humerus (namely, extensor carpi radialis, extensor digitorum communis, extensor digiti quinti, and in part the extensor carpi ulnaris); flexion of the manus by the volar antibrachial muscles (palmaris longus, flexor carpi ulnaris, and flexor digitorum sublimis and profundus); extension of the manus by the dorsal antibrachial muscles (extensor carpi radialis and ulnaris, extensor digitorum communis, extensor digiti quinti, extensor pollicis et indicis and the extensor ossis metacarpi pollicis); while flexion and extension of the digits are produced by the flexor and extensor digitorum muscles, respectively.

Protraction of the shoulder-girdle is brought about by the action of the trapezius and rhomboideus anterior and levator scapulae while retraction is produced by the subclavius, pectoralis minor, trapezius posterior, possibly the serratus anterior and indirectly the latissimus dorsi and posterior portion of the pectoralis major.

The nerves which supply the muscles of the forelimb exhibit no striking peculiarities other than the course which the musculocutaneous, median, ulnar and radial nerves take, namely, round the postero-lateral boundary of the axilla rather than the antero-medial as in typical mammals. The peculiar course of these nerves is indubitably due to the pronounced medial rotation of the brachium.

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ABBREVIATIONS

A—acromion
AB—ventral (axillary) border of scapula
AE—anconeus externus
AI—anconeus internus
AL—acromioclavicular ligament
ATN—anterior thoracic nerves
B—biceps brachii
B′—tendon of biceps
BR—brachialis
C—coracoid
C′—carpus
C″—capitulum
CA—capitate
CE—centrale
CF—clavicular facet
CF′—navicular facet
CP—coronoid process
D—deltoid
DB—dorsal (posterior) border
DT—deltoid tuberosity
ECR—extensor carpi radialis
ECU—extensor carpi ulnaris
EDC—extensor digitorum communis
EDQ—extensor digiti quinti proprius
EJ—elbow-joint
EMP—extensor ossis metacarpi pollicis
EP—extensor pollicis et indicis
F—foramen
F′—facet
F″—fossa
FA—falciform bone
FCU—flexor carpi ulnaris
FDP—flexor digitorum profundus
FDS—flexor digitorum sublimis
G—groove
GF—glenoid fossa
GM—greater multangular
GT—greater tuberosity
H—humurus
H^1—hook-like process
H^2—hamate
HA—humeroabdominalis
HD—humerodorsalis
HF—humeral facet
I—infraspinatus
IF—infraspinous fossa
IG—intertubercular groove (canal)
IT—infraglenoid tubercle
L—lunate
L′—latissimus dorsi
L″—tensor fasciae antibrachii
L_1—medial lamina on lesser tuberosity
L_2—lateral lamina (bicipital ridge)
L_3—point of insertion of latissimus dorsi and teres major
LE—Lateral epicondyle
LF—lunate facet
LM—lesser multangular
LS—levator scapulae
LTN—long thoracic nerve
M_{1-5}—metacarpal bones
MCN—musculocutaneous nerve
MN—median nerve
N—navicular
N_{1-2}—notch
NF—navicular facet
NS—median, ulnar and radial nerves
OF—olecranon fossa
OP—olecranon process
P—anterior superficial pectoralis
P′—posterior superficial pectoralis
P″—anterior deep pectoralis
P‴—posterior deep pectoralis
Pb—pisiform
P_{1-3}—phalanges
PL—palmaris longus
PM—pectoralis minor
PR—pectoralis ridge
PT—pronator teres
R—radius
RAC—rhomboideus anterior (cervical portion)
RAO—rhomboideus posterior (occipital portion)
RF—Radial fossa
RF′—radial facet
RN—radial nerve
RP—rhomboideus posterior
S—scapula
S′—supraspinatus
S″—subscapularis
SC—sigmoid cavity
SC′—subclavius
SF—sternal facet
SF′—supracondylar foramen
SF_1—supraspinous fossa
SF_2—subscapular fossa
SJ—shoulder-joint
SM—serratus magnus (anterior)
SN—semilunar notch
S^1N—nerve to subclavius muscle
SP—spine
SS—suprascapula
SSN—suprascapular nerve
S′SN—subscapular nerve
ST—sternum
ST′—subclavian tubercle
T—tuberosity
TA—trapezius anterior
TE—external head of triceps brachii
TI—internal head of triceps brachii
TM—teres major
TM′—teres minor
TN-T′N—nerves to humerodorsalis and humeroabdominalis
TP—trapezius posterior
TR—triquetral
TRO—trochlea
TS—long (scapular) head of triceps brachii
U—ulna
UF—ulnar facet
UN—ulnar nerve

THE COMPARATIVE ANATOMY OF THE THYROID AND ADRENAL GLANDS IN WILD ANIMALS

ROBERT CRILE

The hypothesis underlying the investigation described in the following pages is that the adrenals and the thyroid are the energy-controlling glands of the body; that the energy characteristics of the animal depend primarily on the thyroid-adrenal relationship. Being a gland of steady and continuous activity, one would expect that the thyroid gland would be large in the more highly sensitized and active animals, and that it would be relatively small in those animals that are slow or that carry special means of protection, such as poison, carapace or offensive odor.

In the human being the thyroid gland has more than twice the weight of the adrenal glands. Since man differs in his energy characteristics from animals in the wild state, the question arises whether such animals differ widely from man and from each other with respect to the development of these energy regulators.

The adrenal glands are emergency glands (Cannon), which are called into action for sudden needs rather than for long cycles, like the thyroid gland. Therefore, it may be assumed that the adrenal glands control the explosive outbursts of energy. The secretion of the adrenal gland, discharged into the blood stream, empowers the animal for a short time with a strength and speed far beyond that of its ordinary range.

From the above considerations we inferred that the relative sizes of the adrenal and thyroid glands of animals might vary according to the energy characteristics and habits of the animals. In fact, we believed that the energy characteristics of animals, so far as activity is concerned, might almost be determined by a comparative study of the relative sizes of the thyroid and the adrenal glands and by their relations to the body weights.

To test these points, during the past three years, I have obtained specimens of the thyroid and adrenal glands of a widely separated variety of animals, in order to determine the relationship between the size of the animal and the weights of these important glands as well as the energy characteristics of the animals. The research, although not completed, would seem to support the theory that such relationships exist.

The Crile-Bole-Fuller Expedition was organized in October, 1931. Although the main objective was to secure specimens of the fauna of the Southwestern States, one objective was to secure evidence whereby to test the validity of this theory. The members of the expedition were: Arthur B. Fuller, George W. Phillips, and Benjamin P. Bole, Jr., of the Staff of The Cleveland Museum of Natural History; Harold L. Madison, Jr., and myself, my purpose being to secure weights of the brain, thyroid and adrenal glands of as many species of animals as possible. The research has included three collections:

First: The glands of wild animals collected in Arizona.

Second: The glands of domestic and of wild animals collected in the vicinity of Cleveland, and of wild animals collected from importers and zoological gardens in Cleveland, New York, Detroit, California, etc.

Third: The glands of domestic and of wild animals collected in Cumberland Island, Georgia, and the extreme South of Florida.

All these glands were preserved in Klotz Solution. They were weighed and photographed and submitted to Dr. Allen Graham, of the Cleveland Clinic Foundation, for microscopic examination. Only normal glands are used in the averages given in the following section, entitled, "Findings."

The first collection was secured October-December, 1931, at Agassiz Peak in the Coconino Forest Reserve, near Flagstaff, Arizona; in the San Francisco Crater, immediately overlooking Flagstaff; at Schultz Pass; at Seligman; at Oakland, Arizona; in the Kaibab Forest; in Oak Creek Canyon; in The White Tank Mountains (near Flagstaff, Arizona) and in the Catalina Mountains, at altitudes varying from 2,000 to 12,000 feet. One hundred and seventeen sets of glands were collected in the Southwestern Expedition, including those of small rodents varying in size from the small mountain meadow mouse to the large Mexican pack rat; of the gopher, the prairie dog and the rabbit; of many varieties of squirrels and chipmunks; of several varieties of skunks; of the lynx, coyote, mountain lion, peccary (wild pig); mule deer and white-tailed deer.

On my return to Cleveland, I continued this study of the comparative size of the thyroid and adrenal glands and collected thirty-three sets of glands of such domestic animals and wild animals as could be found about Cleveland, as well as of animals from the zoological gardens of Detroit and Cleveland. However, inasmuch as the thyroid glands of the domestic animals from the slaughterhouses in Cleveland were goiterous, as were those of the wild animals from the Zoological Gardens of Cleveland and Detroit, such as a black bear (*Euarctos americanus*), a baboon (*Cynocephalus hamadryas*), a chita (*Acynonyx jubatus*), an axis or spotted deer (*Cervus axis*), and lions (*Felis leo*) and since Dr. Graham, of the Cleveland Clinic Foundation, found that the thyroid glands of the Arizona white-tailed deer, the peccary, and the coyote collected in Arizona were goiterous, it seemed as if it might be interesting to compare the observations of animals in goiter belts with those of animals that had been bred in a comparatively "goiter-free country," such as Florida which, having ocean on both sides, should not be lacking in iodine.

Through the courtesy of Dr. T. S. Field, Dr. F. W. Beck, and Farris and Company, of Jacksonville, Florida, I had the opportunity to collect eighteen sets of glands of cattle, including bulls, steers and cows, pregnant and non-pregnant animals which in appearance were sleek and rugged. The glands were collected immediately after death. In only four instances out of the series of eighteen, i. e., in 22 per cent of the cases, did the weight of the thyroid gland exceed that of the adrenal glands. In Cleveland, out of a series of twenty-eight, in twenty-two instances, 75 per cent, the weight of the thyroid gland exceeded that of the adrenal glands.

In the winter of 1933, through the courtesy of Dr. P. C. Perry and by permission of Mr. Morrison Carnegie, Mr. Fuller of the Cleveland Museum of Natural History, who was a member of the Southwestern Expedition, and I had the added opportunity of collecting various types of wild animals from Cumberland Island, one of the most southern of the Golden Islands of Guale. Cumberland Island afforded an untouched wild life from which were collected specimens of the Florida white-tailed deer, wild pig, raccoon, pocket gopher and alligator. From Southern Florida we secured a crocodile as well as an alligator, representing the sluggish, inactive type of animal, a direct contrast to the alert, habitually active deer.

FINDINGS

MICE

(*Microtus alticola alticola; Peromyscus; Sorex vagrans monticola; Onychomys*—Mountain Meadow Mouse; Deer Mouse; Shrew; Grasshopper Mouse)

Characteristics: These four types of mice differ considerably in characteristics. Where we found them, the Shrew (*Sorex vagrans monticola*) is the smallest, the Deer Mouse (*Peromyscus*) is next in size, and the Mountain Meadow Mouse (*Microtus alticola alticola*) and the Grasshopper Mouse (*Onychomys*) are the largest. I understand, however, that in different parts of the country the relative sizes of these four types vary.

The *Sorex vagrans monticola* and the *Onychomys* are faster and more active than the *Microtus* or the *Peromyscus*. The *Peromyscus* travels on top of the ground; the *Microtus* moves in tunnels. The *Onychomys* lives largely in trees, and, like the *Sorex*, chases and eats the others.

The Thyroid Gland: In all of these varieties of mice the thyroid lobes appeared as long, reddish bodies, lying one on either side of the larynx and a little below it. There was probably an isthmus but it was broken by the slightest pressure. The lobes lay close to the trachea and usually were bound down by a little overlying tissue.

The Adrenal Glands: The adrenal glands in these four types of mice lay at the upper tip of the kidneys. In the *Microtus*, the *Peromyscus* and the *Onychomys* they were so closely attached to the kidneys by a thin membrane of tissue that they seemed to be a part of the kidneys. In the *Sorex* they were separated from the kidneys, lying nearer the blood supply. In shape the adrenal glands were oval or more nearly round; in color, greyish.

Relative Sizes of the Thyroid and Adrenal Glands: In the *Onychomys* (Grasshopper Mouse) the average weight of the thyroid gland was 1.23 mg.; of the adrenal glands, 29.16 mg.; the adrenal glands thus being 23.7 times as large as the thyroid gland (Plate I, Figure 1). In the *Sorex vagrans monticola* (Shrew), the weight of the thyroid gland was 1.6 mg.; of the adrenal glands, 6.2 mg., the adrenal glands being 3.9 times as large as the thyroid gland (Plate I, Figure 2). In the *Microtus alticola alticola* (Mountain Meadow Mouse) the average weight of the thyroid gland was 2.2 mg.; of the adrenal glands, 8.12 mg., the adrenal glands being 3.7 times as large as the thyroid glands (Plate I, Figure 3). In the *Peromyscus* (Deer Mouse), the average weight of the thyroid gland was 2.25 mg.; of the adrenal glands, 6.4 mg., the adrenal glands being 2.8 times as large as the thyroid gland (Plate I, Figure 4).

SQUIRRELS

(*Sciurus fremonti mogollonensis, Sciurus arizonensis, Sciurus aberti*—Pine or Red Squirrel, Grey Squirrel, Abert's Squirrel)

Characteristics: The Pine or Red Squirrel (*Sciurus fremonti mogollonensis*) is extremely alert, not timid, and very active, leaping about in the trees at high speed all day and far into the night. It does not hibernate.

The Arizona Grey Squirrel (*Sciurus arizonensis*) is larger than the Pine or Red Squirrel. In activity it ranges between the Pine or Red Squirrel and the Abert's Squirrel and is more wary than the Pine Squirrel. It partially hibernates in the winter.

The Abert's Squirrel (*Sciurus aberti*) is larger and less active than either the Pine or Red Squirrel or the Arizona Grey Squirrel. In comparison, the Abert's Squirrel is a fat and lazy animal, not alert and not timid.

The Thyroid Gland: In the Pine or Red Squirrel, the lobes of the thyroid gland were long and red and were connected by an isthmus. The position of the lobes was the same as that of the thyroid glands in mice, but the gland was larger in relation to the size of the animal.

In the Arizona Grey Squirrel the lobes of the thyroid gland were long and were connected by an isthmus.

In the Abert's Squirrel the thyroid gland was a little larger than in the Pine or Red Squirrel.

The Adrenal Glands: In the Pine or Red Squirrel the adrenal glands were grey. They lay almost under the kidneys and out of sight. They were long and sausage-like in shape, and were so closely attached to the kidney that they were often flat on one side.

In the Grey Squirrel the adrenal glands were yellowish and long. They lay at the inner side of the kidneys.

In the Abert's Squirrel the adrenal glands were roundish but small. They lay at the upper-inner tip of the kidneys and extended downward.

Relative Sizes of the Thyroid and Adrenal Glands: The average weight of the thyroid glands of the *Sciurus fremonti mogollonensis* (Pine or Red Squirrel) was 9.5 mg.; of the adrenal glands, 86.9 mg., the adrenal glands being 9.15 times as large as the thyroid gland (Plate I, Figure 5).

In the *Sciurus arizonensis* (Grey Squirrel) the weight of the thyroid gland was 26 mg.; of the adrenal glands, 197 mg., the adrenal glands being 7.58 times as large as the thyroid gland (Plate I, Figure 6).

In the *Sciurus aberti* (Abert's Squirrel) the average weight of the thyroid glands was 30.1 mg.; of the adrenal glands, 204 mg., the adrenal glands being 6.77 times as large as the thyroid gland (Plate I, Figure 7).

CHIPMUNKS AND GROUND SQUIRRELS

(*Eutamias*, *Ammospermophilus*, *Citellus*, *Callospermophilus*—
Chipmunk, Antelope Chipmunk, Ground Squirrel,
Mantle Ground Squirrel)

Characteristics: The Chipmunk (*Eutamias*) is very alert. It is not quite so active as the Pine or Red Squirrel, but is more active than the Abert's Squirrel. It is vegetarian and migratory.

The Antelope Chipmunk (*Ammospermophilus*) is about the size of the Chipmunk and is fully as active, if not more so.

The Ground Squirrel (*Citellus*) is about the size of the Chipmunk and the Antelope Chipmunk, but is not so active as either.

The Mantle Ground Squirrel (*Callospermophilus*) is less active than the Pine or Red Squirrel, more active than the Abert's Squirrel, and less active than the Chipmunk. In size, it is about twice as large as the Chipmunk.

The Thyroid Gland: In the Chipmunk the thyroid gland consisted of two lobes lying one on either side of the larynx, and it had an isthmus.

In the Antelope Chipmunk the lobes of the thyroid gland were long and red but small, and lay below the larynx.

In the Ground Squirrel the lobes of the thyroid gland were long and red, but small.

In the Mantle Ground Squirrel the lobes of the thyroid gland were light red, long and large, and were connected by an isthmus.

The Adrenal Glands: In the Chipmunk the adrenal glands were long and grey and lay under the kidneys like those of the Pine or Red Squirrel. In comparison with the adrenal glands of the Pine or Red Squirrel, they were smaller but were larger than those of the Abert's Squirrel.

In the Antelope Chipmunk the adrenal glands were large and grey and long. They lay at the upper-inner tip of the kidney, extending almost to the center of the kidney.

In the Ground Squirrel the adrenal glands were brown in color, long and small. They lay at the upper-inner tip of the kidney and extended down toward the center, lying very close to the kidney.

In the Mantle Ground Squirrel the adrenal glands were yellowish in color, long and large. They lay at the upper-inner side of the kidney.

Relative Sizes of the Thyroid and Adrenal Glands: The average weight of the thyroid glands of the *Eutamias* (Chipmunk) was 2.03 mg.; of the adrenal glands, 15.08 mg., the adrenal gland being 7.4 times as large as the thyroid gland (Plate I, Figure 8).

The average weight of the thyroid glands of the *Ammospermophilus* (Antelope Chipmunk) was 6.4 mg.; of the adrenal glands, 39 mg., the adrenal glands being 6.09 times as large as the thyroid gland (Plate I, Figure 9).

The weight of the thyroid gland of the *Citellus* (Ground Squirrel) was 4 mg.; of the adrenal glands, 19 mg., the adrenal glands being 4.75 times as large as the thyroid gland (Plate I, Figure 10).

The weight of the thyroid gland of the *Callospermophilus* (Mantle Ground Squirrel) was 9.5 mg.; of the adrenal glands, 35 mg., the adrenal glands being 3.68 times as large as the thyroid glands (Figure 11).

PRAIRIE DOG

(*Cynomys*)

Characteristics: Although the Prairie Dog (*Cynomys*) is supposed to be an active animal and covers quite a bit of ground in the vicinity of its hole, it is a timid animal and depends upon its ability to get into its hole quickly in order to escape its enemies. So, although its activity is limited in range, it is alert and runs rather fast for its size. The Prairie Dog begins its hibernating season in November, and at the time of our expedition many of them were in hibernation.

The Thyroid Gland: The thyroid gland of the Prairie Dog was large, red and long, usually lying below the larynx.

The Adrenal Glands: The adrenal glands were brown, oval and small, lying on a level with the upper-inner tip of the kidney, but quite separated from the kidney.

Relative Sizes of the Thyroid and Adrenal Glands: The average weight of the thyroid gland of the *Cynomys* (Prairie Dog) was 25 mg.; of the adrenal glands, 28 mg., the adrenal glands being 1.12 times as large as the adrenal glands (Figure 12).

POCKET GOPHER

(Thomomys)

Characteristics: The Pocket Gopher (*Thomomys*) relies entirely upon its digging powers for food and escape. It is not a very active animal, that is, it does not cover much ground, but is alert and possesses a well-developed pair of front legs with which it digs for roots and digs tunnels in which to store them.

The Thyroid Gland: In each of the series of 39 gophers examined, the thyroid gland consisted of two lobes, dark reddish in color and almost oval in shape. The lobes were not very long and were flat on the inner side. They lay on either side of the larynx, but below and entirely separated from it.

The Adrenal Glands: The adrenal glands were dark grey in color, and almost oval in shape. They were larger in some animals than in others and were sometimes flat on one side and occasionally on both sides. They usually lay at the upper-inner side of the kidney, but separated from it by tissue.

Relative Sizes of the Thyroid and Adrenal Glands: The average weight of the thyroid gland of the *Thomomys* (Pocket Gopher) was 3.95 mg.; of the adrenal glands, 11.88 mg., the adrenal glands being three times as large as the thyroid gland (Plate I, Figure 13).

RATS

(*Neotoma, Dipodomys, Mus Norvegicus*—Mexican Pack Rat, Kangaroo-Rat, and Gray Norway Rat)

Characteristics: The Mexican Pack Rat (*Neotoma*) is a bold, lumbering animal with large teeth. It does not show any excessive degree of speed, but works all night carrying away objects which are often in excess of its own weight.

The Kangaroo-Rat (*Dipodomys*) is about the size of the Chipmunk, and its cheek pouches resemble those of the Pocket Gopher. The Kangaroo-Rat burrows beneath rocks. It is more active than the Mexican Pack Rat and has elongated hind legs, large eyes, well developed ears, and a long tail.

The Thyroid Gland: In each of our series of sixteen Mexican Pack Rats the lobes of the thyroid gland were long, reddish-brown in color and were connected by an isthmus. One lobe lay on either side of the larynx, half its length extending over the trachea. In every specimen there was a very definite isthmus.

In the Kangaroo-Rat the lobes of the thyroid gland were dark red and flat. They were wide at the top, narrower toward the base and lay right over and extended below the larynx and were connected by an isthmus.

The Adrenal Glands: In the Mexican Pack Rat the adrenal glands were light grey in color. They were long and often were attached to the kidneys, being flat on the attached side and rounded on the other. In most cases they were attached at the middle of the upper end of the kidneys and were held down by a thin membrane, but in some instances they lay near the inner side of the upper end of the kidneys and were separated from them by tissue.

In the Kangaroo-Rat the adrenals were grey and oval. They lay at the inner-lower end of the kidneys, separated by tissue.

Relative Sizes of the Thyroid and Adrenal Glands: In the *Neotoma* (Mexican Pack Rat) the average weight of the thyroid gland was 11.1 mg.; of the adrenal glands, 61.7 mg., the adrenal glands being 5.56 times as large as the thyroid gland (Plate I, Figure 14).

In the *Dipodomys* (Kangaroo-Rat) the average weight of the thyroid gland was 1.15 mg.; of the adrenal glands, 6 mg., the adrenal glands being 5.22 times as large as the thyroid gland (Plate I, Figure 15).

In the ordinary *Mus Norvegicus* (Grey Norway Rat) which is large, alert, and fierce, the thyroid gland was 8 mg.; the adrenal glands, 62 mg., the adrenal glands being 7.75 times as large as the thyroid gland (Plate II, Figure 16).

MUSK-RAT OR MUSQUASH

(*Ondatra zibethica*)

Characteristics: The Musk-Rat is largely a water animal. It is slow and massively built, the average weight being about two pounds. In character it is sly but, like the brown rat, it may be very savage. Its food consists of grasses, fish, and even carrion.

Relative Sizes of the Thyroid and Adrenal Glands: In the *Ondatra zibethica* (Musk Rat) the weight of the thyroid gland was 43 mg.; of the adrenal glands, 156 mg., the adrenal glands being 3.63 times as large as the thyroid glands (Plate II, Figure 17).

WOODCHUCK

(*Marmota monax monax*)

Characteristics: The Woodchuck does not store food for the winter. It hibernates completely. Its average weight is from eight to ten pounds. Although we had several Woodchucks in our series, those in hibernation and just out of hibernation were of special interest.

Relative Sizes of the Thyroid and Adrenal Glands: One of our specimens of *Marmota monax monax* (Woodchuck) was dug out in early winter while still asleep, and was killed instantly. The weight of the thyroid gland was 197.5 mg.; of the adrenal glands, 172.5 mg., *the thyroid gland being 1.14 times as large as the adrenals.*

A second Woodchuck was caught in February, just as it was coming out from hibernation. It moved slowly, was easily caught, caged and brought to the Cleveland Clinic where it showed little activity or desire to eat. After three days it was killed. The weight of the thyroid gland was 240 mg.; of the adrenal glands, 404 mg., *the adrenal glands being 1.68 times as large as the thyroid gland.*

Thus in two animals of practically the same weight the thyroid and adrenal glands weighed respectively 42.5 mg. and 231.5 mg. more in the animal just out of hibernation than in the animal in hibernation, while in the animal in hibernation the thyroid gland was larger than the adrenal glands and in the animal out of hibernation this relation was reversed, the adrenal glands being larger than the thyroid gland.

RABBITS

(*Silvilagus auduboni; Lepus californicus*—
Cotton Tail Rabbit; Jack Rabbit)

In the Cotton Tail Rabbit (*Silvilagus auduboni*), caught near Cleveland, the average weight of the thyroid gland was 3.7 mg.; of the adrenal glands, 86.3 mg., the adrenal glands being 23.3 times as large as the thyroid gland (Plate II, Figure 18).

In our one Jack Rabbit (*Lepus californicus*) of Arizona, the thyroid gland weighed 147 mg., the adrenal glands 256 mg., the adrenals being 1.74 times as large as the thyroid gland (Plate II, Figure 19).

The average weight of the Cotton Tail Rabbit is 2.5 pounds; of the Jack Rabbit, 6 pounds.

RACCOON

(*Procyon lotor*)

Characteristics: The Raccoon (*Procyon lotor*) is carnivorous. It hibernates during the severe part of the winter. It is about 36 inches long, including its eight to ten-inch tail, and weighs from fifteen to twenty-five pounds.

Relative Sizes of the Thyroid and Adrenal Glands: In the *Procyon lotor* (Raccoon), collected in Cumberland Island, Southern Georgia, in December, the weight of the thyroid gland was 222 mg., of the adrenal glands, 1,651 mg., the adrenal glands being 7.4 times as large as the thyroid gland.

FOXES

(*Urocyon cinereoargenteus scotti; Vulpes fulva*—Grey Fox; Red Fox)

Characteristics: Our series of Grey Foxes was collected in Arizona. The Grey Fox (*Urocyon cinereoargenteus scotti*) is an active, carnivorous animal, but does not depend on sudden outbursts of energy as does the deer. Its average weight is seven pounds.

The Thyroid Gland: The thyroid gland was long and lay below the larynx.

The Adrenal Glands: The adrenal glands were greyish-yellow in color, flat on one side and round on the other. They lay on the inner side of the kidneys but were separated from them. In two out of our six specimens the adrenal glands were not found in the same position in relation to the kidneys, and were constricted in the center, like a peanut.

Relative Sizes of the Thyroid and Adrenal Glands: The average weight of the thyroid glands of the *Urocyon cinereoargenteus scotti* (Grey Fox) was 112.8 mg.; of the adrenal glands, 279.1 mg., the adrenal glands being 2.48 times as large as the thyroid gland (Plate II, Figure 20).

Our one specimen of the Red Fox (*Vulpes fulva*) was secured near Cleveland.

The Thyroid Gland: The thyroid gland seemed to be relatively large.

The Adrenal Glands: The adrenal glands were dissimilar in size, in form, and in their position in relation to the kidneys.

Relative Sizes of the Thyroid and Adrenal Glands: The weight of the thyroid gland of the *Vulpes fulva* (Red Fox) was 405 mg.; of the adrenal glands, 420 mg., the adrenal glands being 1.04 per cent larger than the thyroid glands.

CATS

(*Bassariscus; Felis domesticus*—Ring-Tailed Cat, Domestic Cat)

An interesting comparison was that between the adrenal-thyroid ratio in a Domestic Cat (*Felis domesticus*) and in the Ring-Tailed Cat (*Bassariscus*) secured in Arizona. In the latter the average weight of the thyroid gland was 88 mg.; the adrenal glands 353.5 mg., the adrenals being four times as large as the thyroid gland (Plate II, Figure 21). In the domestic cat the thyroid gland weighed 216 mg.; the adrenal glands 518 mg., the adrenal glands being only 2.4 times as large as the thyroid gland (Figure 22).

SKUNKS

(*Spilogale; Conepatus mesoleucus; Mephitis;* Civet Cat or Spotted Skunk; Hog-Nosed Skunk; Common or Hooded Skunk)

Characteristics: Skunks are slow and deliberate; even when frightened they do not move rapidly. They are carnivorous and hibernate only in severe winters.

The Civet Cat or Spotted Skunk (*Spilogale*) is smaller than the Hooded or Common Skunk and is largely arboreal.

The Hooded Skunk (*Mephitis*) is about the size of a cat, but is heavier and more stockily built.

The Hog-Nosed Skunk (*Conepatus mesoleucus*) is the largest of the three and the least active.

Relative Sizes of the Thyroid and Adrenal Glands: The average weight of the thyroid gland of the *Spilogale* (Civet Cat) was 17.8 mg.; of the adrenal glands, 79.2 mg., the adrenals being 4.4 times as large as the thyroid gland.

The weight of the thyroid gland of the *Mephitis* (Common Skunk) was 96 mg.; of the adrenal glands, 348 mg., the adrenal glands being 3.62 times as large as the thyroid gland (Figure 23).

The average weight of the thyroid gland of the *Conepatus mesoleucus* (Hog-nosed Skunk) was 93 mg.; of the adrenal glands, 277.5 mg., the adrenal glands being 2.98 times as large as the thyroid gland (Figure 24).

PORCUPINE

(*Erethizon dorsatum*)

Characteristics: The Canadian Porcupine (*Erethizon dorsatum*) weighs from fifteen to twenty pounds. It is slow, clumsy and unafraid.

It is largely nocturnal and does not hibernate. Its food consists of leaves, bark, pods, etc.

Relative Sizes of the Thyroid and Adrenal Glands: In the ***Erethizon dorsatum*** (Porcupine) procured from Canada, the weight of the thyroid gland was 360 mg.; of the adrenal glands, 375 mg., the adrenal glands being 1.04 times as large as the thyroid gland.

COLLARED PECCARY

(*Pecari angulatus*)

Characteristics: The peccary (*Pecari angulatus*) is very agile and alert. It climbs mountains like a mountain goat and has great endurance. It moves rapidly for short distances and covers long distances at a time, sometimes twenty miles without a stop. It may be quite savage.

The Thyroid Gland: The lobes of the thyroid glands in our two specimens were very long, varying from three inches in length in one, to four and a half inches in length in the other. In both specimens the lobes were flat and hard and were connected by a wide isthmus.

The Adrenal Glands: The adrenal glands were bluish-grey, large, and approximately oval in shape except that one end was larger than the other and they were well separated from the kidneys.

Relative Sizes of the Thyroid and Adrenal Glands: The thyroid-adrenal ratios of these specimens are invalid as Dr. Allen Graham found both thyroid glands hyperplastic, in fact, in one the hyperplasia was "sufficient to be considered an exophthalmic goiter."

The weights, however, are interesting, if for no other reason than the size of the goiter.

Total Thyroid including isthmus	Total Adrenal
1200 mg	1800 mg.
20000 mg	2600 mg.

DEER

(*Homionus odocoileus*, *Odocoileus couesi*, *Odocoileus virginianus*—
Mule Deer, Arizona White-Tailed Deer, Florida
White-Tailed Deer)

MULE DEER

Characteristics: The period when we were in Arizona was the mating season for the very active migratory Mule Deer (***Homionus odocoileus***) which depends upon speed for its escape from its enemies. It moves in leaps and bounds, all feet leaving the ground simultaneously. For short distances the Mule Deer maintains a very rapid pace. Its weight ranges from 150 to 250 pounds.

The Thyroid Gland: The lobes of the thyroid gland of the Mule Deer were light or dark red in color, long, and with rounded ends. They lay far beneath the larynx with the lower ends out of sight, and had a large blood supply running throughout the gland. In none of our specimens did I find an isthmus.

The Adrenal Glands: The adrenal glands were dark grey, almost brownish in color, and oval in shape. They lay at the upper-inner side of the kidneys which were close to the vena cava.

Relative Sizes of the Thyroid and Adrenal Glands: The average weight of the thyroid glands was 2,725 mg.; of the adrenal glands, 5,425 mg., the adrenal glands being 1.99 times as large as the thyroid gland (Figure 27).

ARIZONA WHITE-TAILED DEER

Characteristics: The Arizona White-Tailed Deer (*Odocoileus couesi*) is only half the size of the Mule Deer. Like the Mule Deer, it covers the ground in leaps and bounds and in comparison with the Mule Deer would seem to be more active. •It climbs mountains with the ease and agility and endurance of a mountain goat. The weight of the Arizona While-Tailed Deer ranges from 100 to 150 pounds.

The Thyroid Gland: The lobes of the thyroid glands of the Arizona White-Tailed Deer were red, large and long and had a large blood supply.

The Adrenal Glands: The adrenal glands of the Arizona White-Tailed Deer were dark, bluish-grey in color. They were large, were flat on both sides and had rounded edges. In some specimens they lay in different positions in relation to the kidneys, but usually they lay at the upper-inner side of the kidneys and were separated from them.

Relative Sizes of the Thyroid and Adrenal Glands: The relative sizes of the thyroid and adrenal glands of the Arizona White-Tailed Deer (*Odocoileus couesi*) are invalid, as Dr. Allen Graham found that all the thyroid glands showed hyperplasia. The weights are interesting, however, the average weight of the thyroid was 2,125 gm.; of the adrenals, 2,550 gm., the adrenal glands being 1.2 times as large as the thyroid gland (Plate III, Figure 26).

FLORIDA WHITE-TAILED DEER

Characteristics: The climate in Cumberland Island where these deer were collected is tropical. The animals live in a jungle of palmetto, underbrush and marsh. They were in poor physical condition, owing to drought, and were infested with parasites.

The Thyroid Gland: The thyroid glands of all of our specimens were pathologically enlarged.

The Adrenal Glands: The adrenal glands in all specimens were solid, roundish bodies.

Relative Sizes of the Thyroid and Adrenal Glands: Although the pathologic enlargement of the thyroid gland of the Florida White-Tailed Deer (*Odocoileus virginianus*) invalidates the thyroid-adrenal ratio, it is worth mentioning that even with pathologic enlargement of the thyroid gland, the average weight of the thyroid glands was 2.46 gm., of the adrenal glands, 2.07 gm., the adrenal glands being 1.08 times as large as the thyroid glands (Plate III, Figure 27).

SEAL

(*Phoco richardii geronimensis*)

This seal had been in captivity for some years in the Brookside Zoo, Cleveland. Its death was due to violence.

Relative Sizes of the Thyroid and Adrenal Glands: The weight of the thyroid gland was 5,204 mg.; of the adrenal glands, 6,003 mg., the adrenal glands being 1.15 times as large as the thyroid gland in spite of the fact that pathological examination by Dr. Allen Graham revealed hyperplastic goiter (Plate III, Figure 28).

BIRDS

(*Buteo borealis*, *Bubo virginianus virginianus*—
Chicken Hawk, Horned Owl)

In a group of birds we found the following relationships between the thyroid and adrenal glands.

Relative Sizes of the Thyroid and Adrenal Glands: In the Chicken Hawk (*Buteo borealis*) the weight of the thyroid gland was 106.5 mg.; of the adrenal glands, 113.5 mg., the adrenal glands being 1.06 times as large as the thyroid gland.

In the Horned Owl (*Bubo virginianus virginianus*) the weight of the thyroid gland was 85 mg.; of the adrenal glands, 165 mg., the adrenal glands being 1.94 times as large as the thyroid gland.

BAT

(*Myotis lucifugus* or *Epitiscus fuscus*)

Relative Sizes of the Thyroid and Adrenal Glands: In the Bat (*Myotis lucifugus*) the weight of the thyroid gland was 3.3 mg.; of the adrenal gland, 5 mg., the adrenal glands being 1.51 times as large as the thyroid gland.

RHESUS MONKEY OF INDIA

(*Macacus rhesus*)

Relative Sizes of the Thyroid and Adrenal Glands: In three specimens of Rhesus Monkey (*Macacus rhesus*) the thyroid glands were normal in position and color, and there was no isthmus. The average weight of the thyroid glands was 194 mg.; of the adrenal glands, 467 mg., the adrenal glands being 2.45 times as heavy as the thyroid gland.

ALLIGATOR

(*Alligator mississipiensis*)

We have had three alligators at the Cleveland Clinic, one which was killed in the wild at Cumberland Island, Southern Georgia, and two which had been in captivity for several years in Florida. All were between nine and ten feet long and weighed from 250 to 300 pounds.

The alligator, though apparently a slow, sluggish animal, is capable of quick action when securing its prey, and at times is very aggressive and savage. In captivity, alligators often fight each other.

The Thyroid Gland: The thyroid gland of the alligator consisted of two small reddish cylindrical lobes with an isthmus and lay just below the bifurcation of the trachea.

The Adrenal Glands: The adrenal glands of the alligator were long and slender and grey. They lay close to, in fact, were almost imbedded in the testes or ovaries and were difficult to locate and to dissect.

Relative Sizes of the Thyroid and Adrenal Glands: The average weight of the thyroid glands was 5,200 mg.; of the adrenal glands, 4,900 mg., the thyroid and adrenal glands thus being about the same weight (Plate III, Figure 30).

CROCODILE

(Crocodilus americanus)

Characteristics: The crocodile is more savage and more swift in action than the alligator.

The Thyroid Gland: The thyroid gland in the crocodile was bi-lobed and lay at the bifurcation of the trachea, one lobe on either side.

The Adrenal Glands: The adrenal glands were long, slender bodies and lay near the testes or ovaries. In shape, they were very much like the adrenals of the alligator.

We have had two crocodiles at the Cleveland Clinic, both of which had been in captivity at Musa Island, Florida, from two to three years.

Relative Sizes of the Thyroid and Adrenal Glands: In the case of one of these specimens the dissection was made out-of-doors under difficult conditions, and I was unable to secure all the adrenal tissue. The weight of the thyroid gland was 3,770 mg.

Another crocodile was shipped from Musa Island to the Cleveland Clinic where it was dissected under favorable conditions. The weight of the thyroid gland of this crocodile was 5,200 mg.; of the adrenal gland, 4,300 mg., the thyroid gland being 1.2 times as heavy as the adrenal glands. Pathologic examination of the thyroid gland revealed no hypertrophy or hyperplasia.

MOUNTAIN LION OR PUMA

(Felis concolor)

The Mountain Lion was secured in Arizona.

Characteristics: The Mountain Lion (*Felis concolor*) is an alert, lithe, active animal. It covers a large range of territory, is stealthy in its hunting, finally rushing upon its prey in a series of leaps, or springing down upon it from an elevation. It averages from three to four feet in length from the head to the root of the tail.

The lobes of the thyroid gland of the Mountain Lion were long and were connected by an isthmus.

The adrenal glands were triangular in shape. They were flat on both sides, but wide at the top. The left adrenal gland lay below the central line of the kidney, while the right adrenal gland lay above the central line of the kidney.

Relative Sizes of the Thyroid and Adrenal Glands: The thyroid gland in our specimen weighed 1,600 mg.; the adrenal glands, 4,100 mg., the adrenal glands being 2.56 times as large as the thyroid gland (Plate III, Figure 29).

AFRICAN LION

(*Felis leo*)

This research into the comparative anatomy of the thyroid and adrenal glands began in 1927 when Dr. George Crile, on a hunting expedition in Africa, made rough dissections of lions and antelopes in the field, finding in every instance that the adrenal glands were noticeably larger than the thyroid gland, exactly opposite to the relative sizes of these glands in man in whom the weight of the thyroid gland is approximately twice that of the adrenal glands. It was this observation that led to my participation in the Southwestern expedition of the Cleveland Museum of Natural History.

In all, we have dissected five lions at the Cleveland Clinic. The first was a full grown female of jungle-born parents, which was bred in captivity. It was purchased from the Detroit Zoological Gardens, which are within the goiter belt. Dr. Allen Graham examined the thyroid gland and found a colloid goiter with hyperplasia.

The second lion was a female, six months old, bred in California. In this lion also Dr. Graham found a large colloid goiter with hyperplasia.

The third lion was a young female killed in combat. The glands were given to the Cleveland Clinic Research Department through the courtesy of Mr. Clyde Beatty. Dr. Allen Graham found a colloid goiter with hyperplasia.

The fourth lion was a mature male, weighing 356 pounds. It was secured from a zoological garden in Pennsylvania where it had been born seventeen years before. It was in good condition. Dr. Graham found a large colloid goiter with hyperplasia.

The fifth lion was a young female, only a year and a half old. It had a goiter.

The data regarding these goiterous animals collected from zoological gardens are introduced merely for general interest, but have no bearing upon our research.

	Thyroid	Adrenals
Lion No. 1	23,500 mg.	14,500 mg.
Lion No. 2	7,418 mg.	7,247 mg.
Lion No. 3	9,170 mg.	5,750 mg.
Lion No. 4	1,412 mg.	24.9 mg.
Lion No. 5	165 mg.	150 mg.

SUMMARY

1. In the wild state, the adrenal glands are larger than the thyroid gland, with a ratio as high as twenty-three to one in certain small rodents. In a human, the thyroid gland is larger than the adrenal glands, the ratio being two to one.
2. According to our data, a larger size of the thyroid gland in relation to the adrenal glands would seem to be a characteristic of the human being only.
3. Domestic animals from the territory in which goiters appear in man had goiters. Wild animals in captivity in these regions also had goiters. Therefore, a comparison of the weights of the thyroid and adrenal glands of these goiterous animals were not of value.
4. In Florida, domestic and wild animals were free from goiter.

APPRECIATION

I wish to express my appreciation to my father, Dr. George Crile, for making these expeditions possible and for permitting me to participate in them. To him I am indebted for the theory to test the validity of which this research was undertaken.

To Dr. E. S. A. King, formerly of the Cleveland Clinic Foundation, and to Dr. E. L. Walsh, I am indebted for their aid in preparing and photographing these specimens. To Dr. Allen Graham, of the Cleveland Clinic Foundation, I am indebted for the pathological examination of the specimens. To Daniel P. Quiring, Ph. D., of Western Reserve University, I am indebted for advice and supervision, and finally, I cannot adequately express my appreciation of the co-operation of every member of the Crile-Bole-Fuller Expedition.

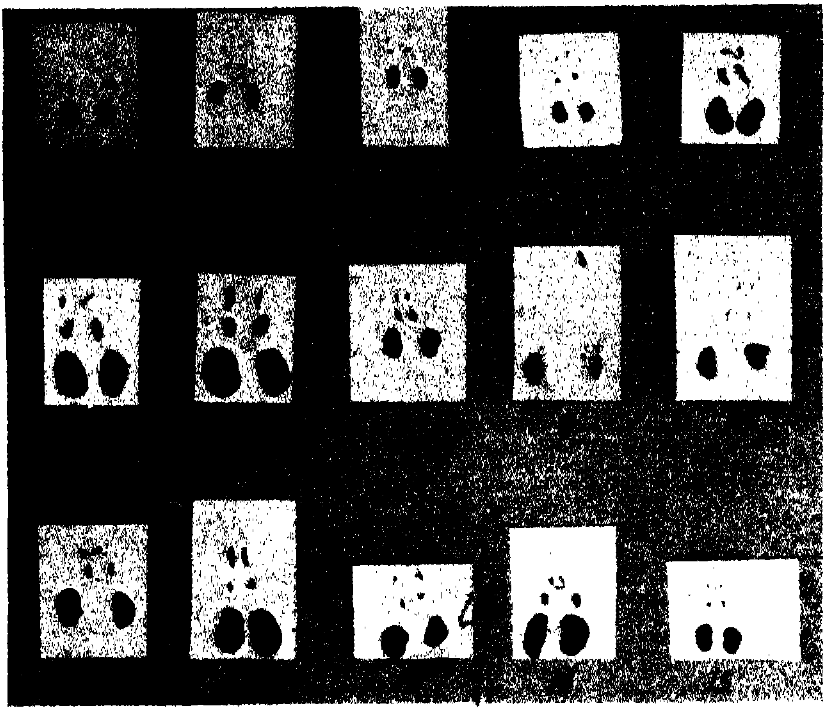
Plates I to IV. Photographs and Relative Weights of the Thyroid and Adrenal Glands in a Series of Thirty Animals

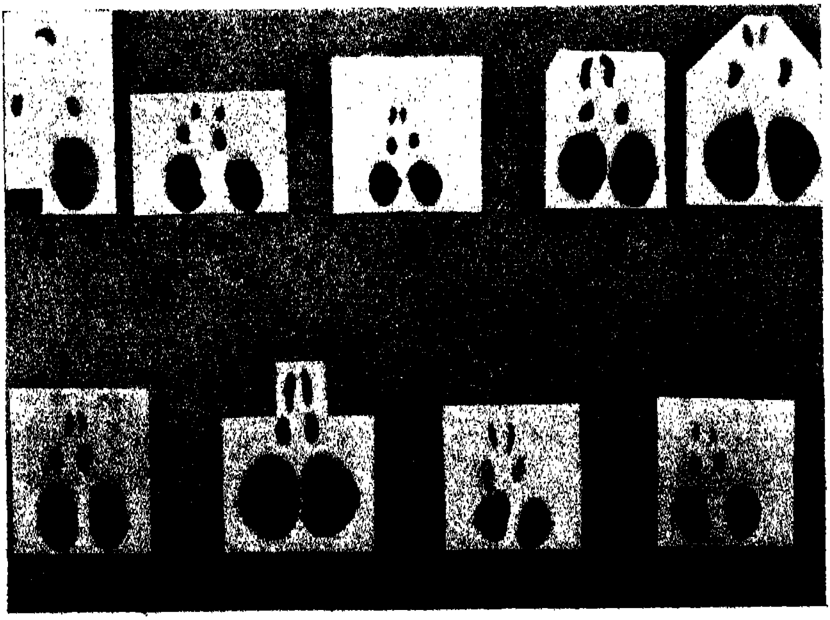
(The numbers correspond to the numbers on the plates.)

No.	Name of Animal	Weight in Grams			Thyroid-Adrenal Ratio
		Thyroid	Adrenals	Kidneys	
1	*Onychomys* (Grasshopper Mouse)	.0014	.04	.392	1 to 28.57
2	*Sorex vagrans monticola* (Shrew)	.0012	.0062	.221	1 to 5.17
3	*Microtus alticola alticola* (Mountain Meadow Mouse)	.0032	.0054	.172	1 to 1.69
4	*Peromyscus* (Deer Mouse)	.0015	.0068	.24	1 to 4.53
5	*Sciurus fremonti mogollonensis* (Pine or Red Squirrel)	.008	.091	1.626	1 to 11.37
6	*Sciurus arizonensis* (Grey Squirrel)	.026	.197	3.335	1 to 7.58
7	*Sciurus aberti* (Abert's Squirrel)	.051	.222	3.536	1 to 4.35
8	*Eutamias* (Chipmunk)	.0012	.020	.608	1 to 16.7
9	*Ammospermophilus* (Antelope Chipmunk)	.0028	.038	.807	1 to 13.57
10	*Citellus* (Ground Squirrel)	.004	.019	1.09	1 to 4.75
11	*Callospermophilus* (Mantle Ground Squirrel)	.0095	.035	1.415	1 to 3.68
12	*Cynomys* (Prairie Dog)	.025	.028	2.564	1 to 1.12
13	*Thomomys* (Pocket Gopher)	.0012	.0085	1.172	1 to 7.08
14	*Neotoma* (Mexican Pack Rat)	.019	.137	2.353	1 to 7.21
15	*Dipodomys* (Kangaroo Rat)	.01	.04	.947	1 to 4
16	*Mus norvegicus* (Gray Norway Rat)	.008	.062	....	1 to 7.75
17	*Ondatra zibethica* (Musk-Rat of Musquash)	.043	.156	5.16	1 to 3.63
18	*Sylvilagus auduboni* (Cotton-Tail Rabbit)	.030	.090	4.630	1 to 3
19	*Lepus californicus* (Jack Rabbit)	.147	.256	19.34	1 to 1.74
20	*Urocyon cinereoargenteus scotti* (Grey Fox)	.160	.371	29.4	1 to 2.32
21	*Bassariscus* (Ring-Tailed Cat)	.080	.387	10.25	1 to 4.84
22	*Felis domesticus* (Domestic Cat)	.216	.518	23.9	1 to 2.4
23	*Mephitis* (Common or Hooded Skunk)	.096	.348	6.91	1 to 3.62
24	*Conepatus mesoleucus* (Hog-Nosed Skunk)	.054	.211	7.51	1 to 3.9
25	*Hemionus odocoileus* (Mule Deer)	2.00	5.750	....	1 to 2.87
26	*Odocoileus couesi* (Arizona White-Tail Deer)	1.650	2.400	85.00	1 to 1.45*
27	*Odocoileus virginianus* (Florida White-Tail Deer)	2.460	2.670	....	1 to 1.08
28	*Phoco richardii geronimensis* (Seal)	5.204	6.003	....	1 to 1.15
29	*Felis concolor* (Mountain Lion)	1.6	4.1	140.00	1 to 2.56
30	*Alligator mississipiensis*	3.5	4.0	....	1 to 1.14

*Histologic examination showed a marked hyperplasia of the thyroid gland.

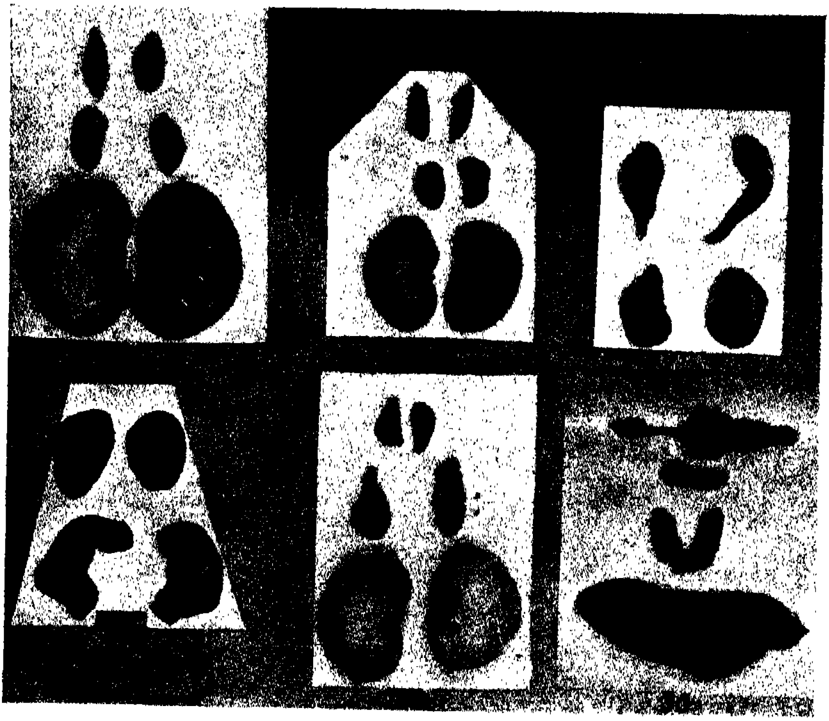
PLATES I AND II

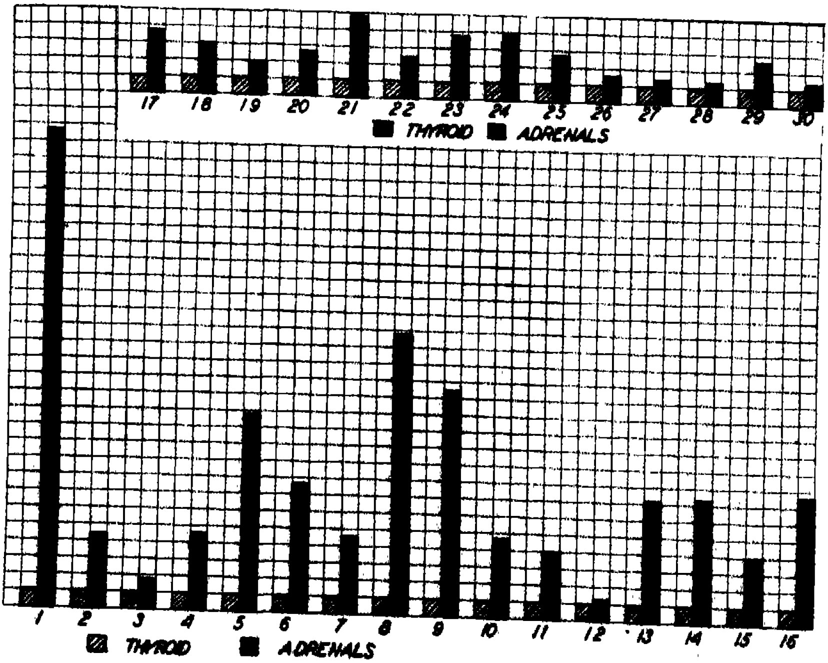




Thyroid and Adrenal Glands
Robert Crile

PLATES III AND IV





NOTE ON THE PRODUCTION OF FRUITING BODIES OF COPRINUS MICACEUS IN CULTURE[1]

S. S. HUMPHREY

During 1927 and 1928, the writer made some studies of the sex reactions of the common glistening ink cap fungus, *Coprinus micaceus* (Bull.) Fr. In this work fruiting bodies were produced in pure cultures started from spores. The methods employed differ in some respects from those used by other investigators of the sex reactions of the higher Basidiomycetes and, with the results, may prove of interest to many in the botanical field.

Fruiting bodies of *Coprinus micaceus* were found growing abundantly in several locations within a few city blocks of the Ohio State University campus and thus a constant source of supply was assured throughout most of the summer. This fungus is often found in lawns, where shade trees have been removed and the roots left in the soil. Although not specific for Cottonwood (*Populus deltoides*) it was found growing commonly from the decaying roots of this species. Spore prints were made, by the following method, from fruiting bodies which had reached maturity but had not started to deliquesce. Portions of lamellae a few millimeters in area were removed with a small pair of forceps and placed on a microscope slide. Another slide, which had been previously washed, flamed and cooled was gently pressed to the upper surface of the lamella and a spore print resulted. These slides were stored in slide boxes until they were needed for further work. This was usually within a week of the time when the prints were made. After some practice, spore prints could be obtained in which the four spores from individual basidia retained their original position with respect to each other. These spores were later picked off the slides with a sharp needle as described below. Some experience was found necessary in selecting fruiting bodies in which the spores were in the proper stage of development to make spore isolation by this method possible. If too young, the spores were light colored and so delicate that they were mashed when touched with the isolation needle. If the fruiting bodies were old, the spores were covered by the slime resulting from the deliquescence of the lamellae and adhered to the slide rather than to the needle. When of the proper age the spores were black in color, the spore print was dry, and the spores did not adhere in masses. At this stage individual spores adhered to the point of the isolation needle rather than to the slide and were easily removed.

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[1] Papers from the Department of Botany, Ohio State University, No. 384.

For the reception of isolated spores, Petri dishes were prepared by cementing four ring cells in the bottom of each with beeswax. The covers were then placed on the dishes, which were sterilized in a hot air oven for one hour at 80 degrees centigrade. Square cover glasses, of dimensions which would cover the ring cells, were cleaned, flamed and cooled. In the center of each glass, a drop of dung agar was placed with a loop needle. The cover glasses with the agar drops on the lower surfaces were then placed over the ring cells in the Petri dishes. The dung agar used in this work was prepared by stirring up 300 gms. of fresh horse dung in 1 liter of water and filtering off the resultant liquid through cotton. To this was added 18 gms. of agar and the mixture heated until the agar dissolved. Where the medium was unusually opaque it was clarified with egg albumen. This is essentially the same medium as used by Newton (1926).

Working under a 16 mm. objective of the microscope, individual spores were picked up from the spore print slides with a sharp darning needle which had first been passed through several thicknesses of clean linen handkerchief. The 16 mm. objective gives ample working space between the lower face of the objective and the spore print slide. When a given spore was selected for transfer, all surrounding spores were first swept away with the needle. The needle was then cleared of spores by passing through the handkerchief several times and the desired spore touched with the needle, to which it adhered. When the spore had been picked up, the needle was thrust into a drop of agar on the lower surface of a cover glass, and the cover glass returned to its ring cell. The Petri dish, without cover, was then placed under the microscope and the drop examined through the cover glass to verify the spore transfer and also to make certain that no other spores had been transferred with the one desired. Since the spores were black and the medium clear amber in color, this could be easily done. In cases where the four spores of a single basidium were isolated, these were placed separately in the four ring cells of one Petri dish. The spores were then examined daily until germination was observed, when the agar drops containing the germinated spores were transferred with a sterile needle to separate tubes of dung agar. By this method of spore isolation, which follows mainly that described by Hanna (1924), some 120 spores were isolated. Of these, 35 germinated and developed monosporous mycelia in the tubes to which they had been transferred.

These monosporous cultures were planted together in pairs on dung agar in plates. After a period of about one week, the mycelium in the plates was examined for the presence of clamp connections which is considered by most investigators to be evidence that hyphal fusion has occurred. In all, 79 of these pairings of monosporous mycelia were made and clamp connections were found to be present in abundance in 39 of the plates, while in 40, no clamp connections could be found. If the presence of clamp connections is an indication that hyphal fusion has occurred and is consequently a good criterion of the diploid condition of the mycelium resulting from certain of the pairings of monosporous mycelia, then monosporous cultures of *Coprinus micaceus* are unisexual rather than bisexual, since only those monosporous mycelia resulting from spores of opposite sex were capable of hyphal fusion. The unisexual nature of monosporous cultures of this species had previously been reported by Vandendries (1926) although this was unknown to the writer at the time.

An attempt was made to grow typical fruiting bodies of this fungus from mycelium which bore clamp connections. About one inch of sand was placed in the bottom of each of four small beakers and on this was placed one-half inch of a mixture of decayed cottonwood and horse dung. The beakers were then sterilized for one hour at 15 pounds pressure and, after cooling, agar from those Petri dishes which contained mycelium having clamp connections was placed on the mixture. The beakers were covered with cheese cloth and placed under one of the greenhouse benches. The cultures were watered with an atomizer through holes in the cheesecloth covers, care being taken not to saturate the soil. In about one month the first small "buttons" of the fruiting bodies appeared in two of the beakers. These later grew above the soil and expanded in the usual manner.

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Hanna, W. F. 1924. The dry-needle method of making monosporous cultures of Hymenomycetes and other fungi. Ann. Bot. 38: 791–795.

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Tissue Immunity

Immunity has been studied from the humoral and cellular aspects for about forty-five years, but only recently has the importance of local tissue reaction been emphasized. Kahn's book is essentially a monograph embodying his own extensive and detailed experiments in this field. It deals principally with serological reactions and grossly observable tissue changes as they bear on the problem of tissue immunity. No histological studies are included. On the basis of this experimental structure the author considers various theoretical and clinical applications. The style leaves little doubt regarding the author's meaning but for the general reader the book is overburdened with experimental detail and repetition. For those in the immediate field who might wish to repeat or extend the work such detail would be essential.

The author holds that allergy and hypersensitivity are phases of immunity; that it is illogical to believe the host acts in a manner against his own interests (e. g., anaphylaxis) except when antigens are introduced in unnatural ways or amounts. He believes that the first and most fundamental evidence of an immune state is the capacity of tissue to anchor locally injected antigen. This is manifested usually by inflammation but if too much free antigen is present there may be necrosis. The appearance of humoral antibodies is secondary and they may disappear from the blood stream long before the capacity for tissue reaction is lost. In this sense incomplete proteins, such as gelatin, may act as antigens, for they are shown to be capable of evoking specific tissue response.

Effective use is made of an ingenious technic to follow local fixation of antigen. Rabbits are immunized against horse serum and then injected with diphtheria toxin. Now if antitoxic horse serum is injected into a certain tissue it will be more or less firmly anchored at the site of inoculation and will be unable to diffuse throughout the animal to neutralize the toxin. Accordingly much larger quantities of antitoxin will be required to prevent toxic death in the horse serum-immunized animals as compared with normals. The technic is applied to various tissues in various phases of active and passive immunity.

There can be no doubt that the author brings important experimental contributions to this field. One feels that he carries some of his theoretical applications rather far and occasional misconceptions are noted; for example, in the chapter on the reactions of young animals the inference is made that embryonic tissue possesses high defensive capabilities as compared with mature tissue. Yet there is little experimental evidence in the literature to support this assumption, in fact, the opposite seems more probable. The author refers repeatedly to the formation of insoluble immune globulin by local tissue cells, but there is no indication in the text that this is more than a mere hypothesis. In general, however, the speculative material is not introduced in an offensive manner but rather for the purpose of supplying a working basis for further thought and investigation. Immunologists and bacteriologists generally may profit by reading this work and clinicians too will find that it sheds new light on many phenomena with which they come into daily contact.—O. C. WOOLPERT.

Tissue Immunity, by Reuben L. Kahn. xix+707 pp. Springfield, Charles C. Thomas, 1936. $7.50.

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SOME CYTOLOGICAL OBSERVATIONS ON PERIPHERAL MYELINATED NERVE FIBERS AS OBSERVED BY THE POLARIZED LIGHT METHOD

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INTRODUCTION

Most neurological procedures depend upon the constancy of the artefacts produced by fixation and staining. Many observations have been made on living or freshly killed tissues with limited results. George St. de Renyi ('29), in particular, has studied nerve fibers by the microdissection method in an attempt to determine the actual cytological characteristics of the fiber while its protoplasm is in a living condition. His findings are of the greatest interest although his negative results in regard to certain structures leave the problem open to further investigation. In a previous paper of one of us (Setterfield and Sutton, '35) it was pointed out that we believe we approximate the observation of unaltered protoplasm by using the polarized light method. This technique has tended to demonstrate the existence in vivo of many of the cytological features which have been described by means of staining methods. It is our purpose in this paper to describe some of these structures as seen in polarized light and compare them with the same structures as they are usually described and illustrated in standard text books on the subject, notably Ramon y Cajal ('28) in his "Degeneration and Regeneration of the Nervous System," Volume one.

MATERIALS AND METHOD

The materials for this study are nerves from the brachial plexus, lumbo-sacral plexus and nerves from the lumbar area, from man, monkeys, dogs, cats, and rats suffering from various pathological conditions. Normal nerves used for comparison were removed from healthy rats, cats, dogs, and monkeys. The source of the nerve trunk for each submitted photomicrograph is identified in its accompanying legend.

As the polarized light technique has been discussed in the paper previously cited, it is useless to do so here.

DISCUSSION

It may be objected that the structures described are not normal but the result of pathological changes. It is true that some of the structures observed are almost or quite invisible in the normal nerve fiber in polarized light; but this is equally true of many structures described by Cajal and others, as their cases were usually from animals following operative procedures and occurring in early stages of degeneration. In other words, our purpose is not to determine the normality of the structures in question but to try to identify them as artefacts or actual structures in the living nerve fiber. Furthermore, the study of nerve trunks removed from patients or from experimental animals suffering from pathological conditions secondarily affecting the peripheral nervous system is well adapted to this type of cytological study as the changes produced are more gradual and much less intensive. Also, since the nerve trunks have not been operatively cut the fibers remain in their own sheaths, thus eliminating the possibility of entrance of foreign material or the escape of protoplasm normally found in the fiber.

As has been pointed out in the paper cited above, swelling of the fibers with seemingly great increase in fluid content is the first and most striking early manifestation of disease in nerve fibers. This type of pathological change is essentially similar to cloudy swelling noted in all other portions of the body suffering from disease. So far as we have been able to determine this swelling does not alter the optical properties of the various parts of the fiber, merely serving to more clearly delimit details due to their greater size and separation from surrounding structures.

Attention was directed in another paper (Setterfield and Baird, '36) to the fact that the axis cylinder, sheath of Schwann, cementing disk, neurokeratin, and the incisures of Schmidt-Lantermann are isotropic in polarized light while the myelin itself is the only birefringent structure in the nerve fiber. We must now point out further that there are differences in the appearance of some of these structures when carefully examined. Specifically, the true axis cylinder (see below), in polarized light, is deep black at all points in the rotation of the stage of the microscope. On the other hand, the cementing disk, though isotropic (that is, not changing from black to white with rotation of the stage) is not as intense a black as the true axis cylinder. Similarly, the non-neurofibrillated portion of the axis cylinder (see below) is slightly less intensely black than the cementing disk, though unchanging during the rotation of the stage. In addition to these structures, still others show less intensities of blackness in the following order: neurokeratin (slightly degenerated), perineurium, bracelets of Nageotte, and the sheath of Schwann. The perineurium is a brownish-gray at all points of stage rotation; the bracelets of Nageotte a medium gray, and the sheath of Schwann a pale gray. These intensities of blackness and whiteness are constant for the structure and are all indicative of isotropism which is manifested by the failure to change from black to white during the rotation of the stage. On the other hand, the myelin sheath, as the stage is rotated, changes from deep black to white four times in each revolution. It is the only anisotropic substance in the fiber. All the remainder are isotropic, but with varying degrees of blackness and whiteness to the eye and to the photographic plate.

In considering the nerve trunk as a whole it might be said in passing that the epineurium appears to be birefringent. Due to the contraction of its connective tissue fibers after death this birefringent appearance might be due to an optical phenomenon resulting from the passing of polarized light through this wavy tissue. Since it is not nervous tissue, it has not been the object of extended study.

Cajal ('28) stated that fixation of nerve trunks in formalin resulted in a shrinkage of the myelin sheath. An extended study was made by one of us (H. M. W.) on this phase of the problem. Nerves removed at cancellation were divided and one-half immediately frozen, sectioned and observed. The remaining half of the nerve trunk was allowed to remain in a fifteen per cent. aqueous solution of formalin for variable lengths of time, up to six weeks. Although it was impossible to obtain actual measurements it was felt that no shrinkage had occurred while in formalin. Due to the necessity of making thin sections the unfixed tissue so badly crumbled as to make photographic recording unsatisfactory.

Two semi-diagrammatic drawings have been included in this paper presenting in visual form the writers' conception of two physiological phases of nerve fibers of the peripheral nervous system. These drawings do not show exact quantitative differences in blackness and whiteness but have been exaggerated for purposes of illustration.

OBSERVATIONS

Bracelets of Nageotte (Fig. 1 and Drawing 1 and 2), as viewed in polarized light, seem to be paired cup-like structures with their bases approximating the cementing disk and their sides extending outward into the myelin sheath and a little nearer the sheath of Schwann than the axis cylinder. As to the origin of these structures the writers could not be sure, although it is possible that they represent an inward and upward reflection of the sheath of Schwann, at the level of the cementing disk. Most standard texts describe these structures as a ring of spines projecting away from the cementing disk. It would seem to the writers that this appearance might be due to either the wrinkling of this structure and the subsequent heavy deposition of staining material in the grooves, or to the fact that the nerve fiber has been cut in such a way that the top of the "cup" has been removed. Due to the diagonal cutting of a nerve fiber the bracelets here reproduced in Figure 1 show both these conditions.

The cementing disk (Fig. 2 and Drawings 1 and 2) is another structure that is easily seen in polarized light, appearing as a transversely located plate into whose periphery runs the sheath of Schwann.

The sheath of Schwann (Fig. 6 and Drawings 1 and 2) has the same structural appearance in polarized light as in stained preparations. It is extremely thin, pale gray in color, and thickened slightly at the location of the nucleus of the Schwann cell and as the sheath approaches the node of Ranvier. Spherules of Erlholz could not be observed in the cytoplasm of the Schwann cell. Also the "dust" particles described by Swank and Davenport ('34) were invisible; indicating that the spherules of Erlholz and the "dust" particles do not exhibit the same optical properties as degenerating myelin, although their reaction to osmic acid is the same. The endocellular apparatus of Golgi likewise could not be seen. There are five possibilities regarding the relation of the sheath of Schwann with the cementing disk, none of which could be accurately determined with the neurological method under discussion.

1. The sheath of Schwann may be continuous over each cementing disk.
2. The sheath of Schwann may be contiguous with the substance of the cementing disk.
3. The sheath of Schwann may be reflected backwards, at the cementing disk, over the axis cylinder to form the sheath of Mauthner.
4. The sheath of Schwann may be reflected backwards, at the cementing disk, to form the bracelet of Nageotte.
5. The cementing disk may be formed by the fusing of the sheaths of Schwann from two adjacent internodal segments.

Due to our inability to differentiate the ending of the sheath of Schwann and the beginning of the cementing disk, and to a series of isolated observations during various stages of nerve fiber degeneration, the writers are inclined to favor the fifth hypothesis.

The sheath of Mauthner could not be identified in any fiber we have ever observed.

Myelin, in a normal nerve fiber (Fig. 2 and Drawings 1 and 2), is homogeneous and birefringent. As degeneration phenomena in the nerve fiber progress the myelin (Fig. 4) rapidly becomes isotropic as it changes into its degeneration products.

Neurokeratin (Fig. 3 and Drawings 1 and 2), in the normal nerve fiber, has an index of refraction which is only slightly different from the myelin. It seems, however, that its presence can be traced through the myelin, under oil immersion, as a thin, skeletal system of trabeculae. Therefore the writers feel that, in the normal condition, the very slightly granular appearance of the myelin is due to the presence of the neurokeratin framework. In rather early degenerating fibers this material swells and rapidly becomes black, (as seen in polarized light), thereby facilitating identification.

In the normal condition the axis cylinder (Drawing 2), as commonly referred to in the literature, is seen to be composed of two portions, (1) an inner cylindrical rod and (2) an outer enveloping sheath. The inner cylindrical rod, which we have called the true axis cylinder, is, in polarized light, isotropic, deep black, homogeneous, and of a uniform calibre throughout the length of the nerve fiber. The outer enveloping sheath which Maximow ('34) calls the non-neurofibrillated portion of the axis cylinder is, in polarized light, isotropic but less intensely black than the true axis cylinder, thereby facilitating its identification. Practically every author has described the axis cylinder to be of constant calibre except at two points; an enlargement above and below, and a constriction as it passes through, the cementing disk. By reference to the included drawings it can be seen that it is the non-neurofibrillated portion of the axis cylinder only that is involved in this enlargement and constriction. It is generally assumed that the non-neurofibrillated portion of the axis cylinder is co-extensive with the true portion. In view of our observations on its relation to neurokeratin we have suspected that the non-neurofibrillated portion is related to the myelin segment rather than the true axis cylinder. While we cannot demonstrate conclusively that the non-fibrillated portion is interrupted at the cementing disc, our observations have cast doubt on the assumption of its continuity. At present we are unable to make a definite statement on the question.

In one physiological phase of the normal nerve fiber (Drawing 2) the incisures of Schmidt-Lantermann are extremely narrow with an index of refraction so nearly the same as myelin as to render them almost invisible.

In another phase the relation of the true axis cylinder, the non-neurofibrillated portion of the axis cylinder, and the incisures of Schmidt-Lantermann, is extensively altered. In this phase (Figs. 5, 6, 8 and Drawing 1) it can be seen that the true axis cylinder is, to all appearances, identical with that shown in Drawing 2 with the exception that there are areas which lie in direct contact with material which appears to be myelin. That this portion of the axis cylinder is the functional, and hence the true portion, has been clearly shown in work on anterior poliomyelitis, to be reported on in the future. Whenever fragmentation of the true axis cylinder was observed the animal always exhibited signs of paralysis.

One of the most interesting and, as yet, unexplained conditions in both early degenerating and physiological states of nerve fibers, is that the non-neurofibrillated portion of the axis cylinder seems to split at the level of the innermost part of an incisure of Schmidt-Lantermann. After this splitting it, to all appearances, slides upward and outward over the incisure of Schmidt-Lantermann until it comes into contact with the sheath of Schwann. That this sliding upward involves all of the non-neurofibrillated portion of the axis cylinder from one incisure to another is evidenced by a short area in which the true axis cylinder is in direct contact with myelin. By reference to the drawing it can be seen clearly that the so-called incisures of Schmidt-Lantermann (Figs. 5, 8, and Drawing 1), (which, in reality, are composed of an upward and outward extension of the non-neurofibrillated portion of the axis cylinder over the original incisural structure) together with their inferior prolongations (the non-neurofibrillated portion of the axis cylinder) form a true infundibulum ("funnel"). Through the tube and dilated mouth of the infundibulum is found extending the true axis cylinder. The true axis cylinder can easily be likened to a stream of fluid running through several superimposed funnels.

The presence of neurofibrils is not doubted by most histologists. However, de Renyi ('29) reached the conclusion that there are no neurofibrils in the living nerve fiber of vertebrates he studied. Observations with polarized light have not settled this question to the satisfaction of the writers. In one notable example, illustrated in Figure 7, in a case twelve hours after cutting the nerve, structures were seen which one of us (H. E. S.) firmly believes to be neurofibrils. Up to the present time this is the only nerve studied at that particular length of time after operation and it may be that it is only at this or corresponding stage of degeneration that they are made visible by the swelling within the true axis cylinder and are not yet degenerated to the extent that their identity is lost. In all other cases, both normal and pathological, the true axis cylinder has shown a homogeneous structure throughout.

In a few cases we have been able to see axonal rings (Fig. 8) similar to those described by Cajal. They appear to be condensations of neurokeratin on the surface of the non-neurofibrillated portion of the axis cylinder, never on the true axis cylinder as above defined. They are quite variable in appearance and we do not believe they are present in normal fibers.

The authors wish to call attention in particular to the relation of the neurokeratin framework to the infundibulum and to the myelin. It appears that the neurokeratin, from its greatest concentration immediately surrounding the infundibulum (non-neurofibrillated portion of axis cylinder in some phases of nerve fibers), extends outward through the myelin to reach its minimum of concentration at its junction with the sheath of Schwann into which it seems to blend. This spongy neurokeratin framework contains potential cavities of varying size; potential because they are filled with true myelin.

CONCLUSIONS

1. Polarized light as a neurological technique depends upon the chemical structure and consequent optical properties of the materials observed. Certain lipoids, making up the substance of the myelin, have the property of birefringence while the chemical complex characterizing the other structures of the nerve fiber do not. This, together with a difference in the degree of isotropism of the non-birefringent structures, makes a study of individual structures both easy and accurate.

2. In this technique we believe that we possess a more sensitive, much simpler and more rapid method than any other now in use for the study of myelinated nerve fibers.

3. We have been able to describe in some detail the structure of nerve fibers, in so far as cytological characteristics are concerned. Our observations have tended to verify the existence

in vivo of several structures which some have suspected of being artefacts of staining and to deny the actuality of others described as characteristically present in nerve fibers.

4. Polarized light technique demonstrates the actuality in unstained nerve trunks of the sheath of Schwann, and its nucleus, perineurium, epineurium, myelin, neurokeratin, incisure of Schmidt-Lantermann, infundibulum, true axis cylinder and possibly its neurofibrils, non-neurofibrillar portion of the axis cylinder, cementing disk, bracelet of Nageotte, fissural, and axonal rings.

5. The polarized light method, according to our study, does not demonstrate the following structures: extra-fissural rings, sheath of Mauthner, spherules of Erlholz, "dust" particles, endocellular apparatus of Golgi, and apparatus of Golgi-Rezzonico.

6. We believe that the differences in intensities of blackness and whiteness of the various isotropic structures are due to a difference in thickness, chemical complex, or to a combination of both.

ACKNOWLEDGMENTS

The writers wish to express their appreciation for the co-operation of the following persons:

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3. Dr. J. A. Toomey, of the Cleveland City Hospital, Cleveland, Ohio, for permitting us to use the photomicrograph of a nerve from a monkey suffering from anterior poliomyelitis.
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EXPLANATION OF PLATES

Description of Plate I

Fig. 1. Median nerve of human removed at autopsy. Anatomical Diagnosis: attempted death by hanging; patient remained alive twenty-eight hours without regaining consciousness; edema and severe hyperemia of the lungs and brain. × 1000.

Fig. 2. Median nerve of young monkey removed under ether anesthesia. Anatomical Diagnosis: Caseous tuberculosis of lower left lung. × 1800.

Fig. 3. Median nerve of human removed at autopsy. Anatomical Diagnosis: right ulcerative pulmonary tuberculosis; left caseous pulmonary tuberculosis. × 1000.

Figs. 4 and 5. Median nerve of human removed at autopsy. Anatomical Diagnosis: multiple infarcts of spleen, kidneys, and lungs; acute hemorrhagic gastritis; toxic splenomegalia; etc. × 1000.

Fig. 6. Sciatic nerve of cat removed under ether anesthesia following experimental starvation for two weeks. Anatomical Diagnosis: negative. × 1800.

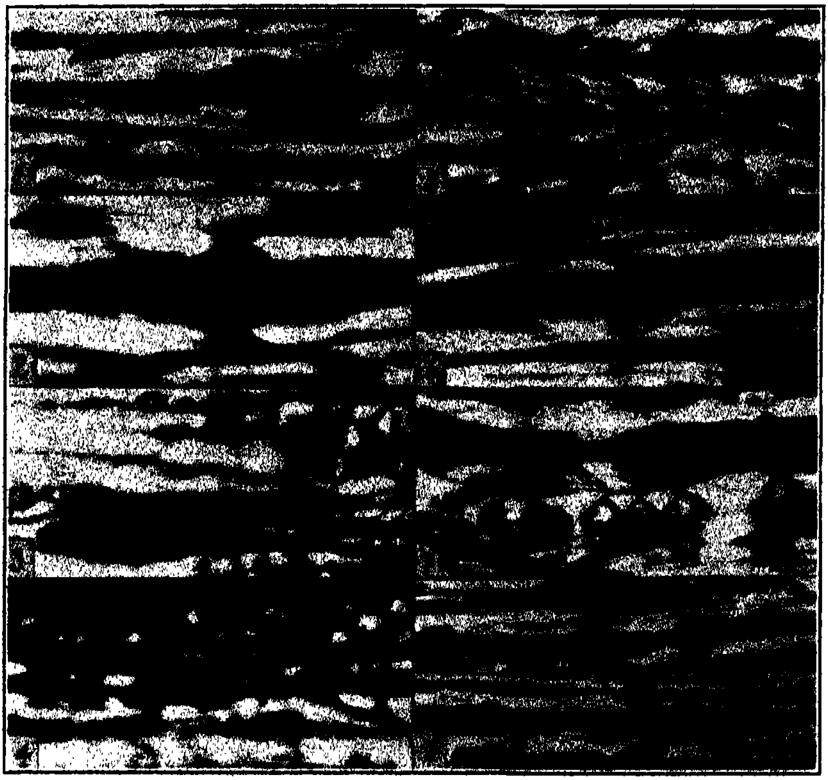
Fig. 7. Peripheral stump of sciatic nerve of an albino rat, twelve hours following surgical section. × 1000.

Fig. 8. Sciatic nerve of a young monkey showing paralysis of the leg for two days following experimentally produced anterior poliomyelitis. × 1000.

Explanation of Figures 1 and 2

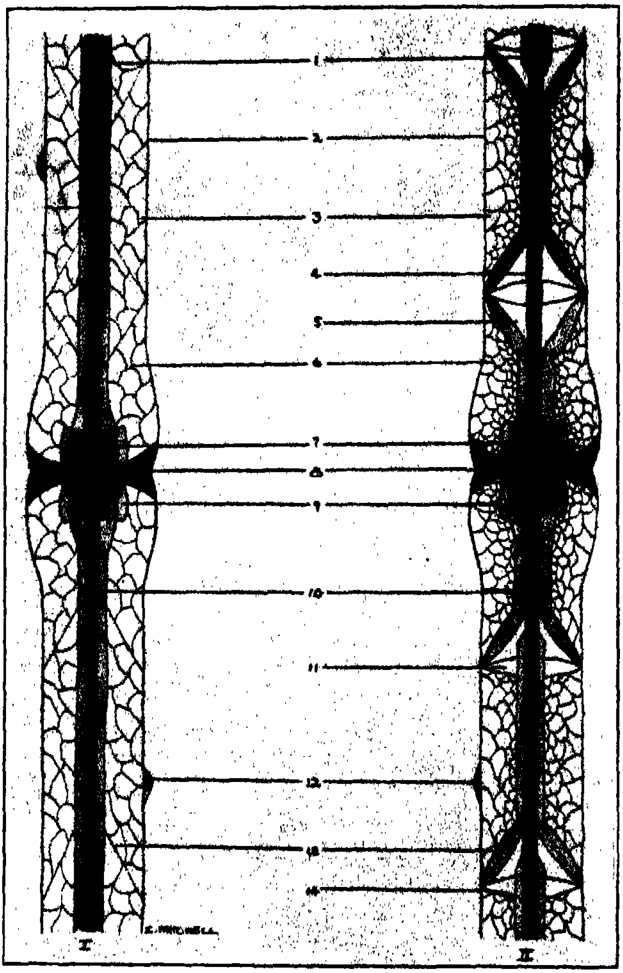
Semi-diagrammatic drawings of two different physiological phases of a normal nerve fiber from the peripheral nervous system.

1. Non-neurofibrillated portion of the axis cylinder.
2. Sheath of Schwann.
3. True myelin.
4. Naked axis cylinder.
5. Infundibulum.
6. Neurokeratin trabecula.
7. Swollen part of non-neurofibrillated portion of axis cylinder.
8. Cementing disk.
9. Bracelet of Nageotte.
10. True axis cylinder.
11. Ostium of Infundibulum.
12. Nucleus of Schwann cell.
13. Incisure of Schmidt-Lantermann.
14. Infundibular ring.



Nerve Fibers in Polarized Light
H. E. Setterfield and H. M. Weaver

FIGURES 1 AND 2



THE DETECTION OF SEX-LINKAGE IN FAMILIES COLLECTED AT RANDOM

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For the genetic study of human characters two methods of collecting families are generally employed. If the character is quite rare the practice of studying only families containing at least one affected child is advisable. The small additional amount of information to be gained through the inclusion of families lacking affected members can in no way compensate for the greatly increased expenditure of time and effort. The method has a distinct advantage over that of random collection of families, since for the simpler types of hereditary behavior it will often be true that only one genotypic combination in the parents can produce affected children, in which cases the estimation of gene frequency and the necessary assumption of an equilibrium population are not required. Where the incidence of the trait is sufficiently high, on the other hand, a random collection of families in which the constitution of the families is disregarded will be found profitable. Moreover, for characters which are not readily recognized or generally reported, or those in which a special test is required, as in blood reactions and taste tests, a random collection cannot well be avoided.

Methods for the analysis of sex-linkage in families selected because at least one child is affected have been given by Hogben (1932), whereas an analysis applicable to randomly collected families has not yet been presented. An additional criterion for sex-linkage, however, has been suggested by Snyder (1934b), who shows that from a random survey of a population, separate estimates of the frequency of the sex-linked recessive gene may be gotten from the proportion of affected males and from the proportion of affected females, the test consisting in a comparison of the two statistics so obtained.

With respect to a sex-linked recessive character the expected proportions of affected sons and affected daughters among children of the various family types are easily deduced in terms of the frequency of the sex-linked recessive gene, q. Where these proportions are dependent upon q, the proportion expected in each case is found by application of the principle of random mating to be $q/1+q$. Designating this proportion by ζ for the sake of simplicity, the offspring proportions for the four family types are as shown in Table I.

TABLE I

Type of Family	Expected Proportion of Affected Individuals	
	Among Sons	Among Daughters
i. Both parents normal	ζ	0
ii. Father only affected	ζ	ζ
iii. Mother only affected	1	0
iv. Both parents affected	1	1

The estimate of ζ is obtained from the observed frequencies of affected males and affected females in the general population from which the families are drawn. In a population at equilibrium with respect to the distribution of a sex-linked pair of alleles the proportions of normal and affected males are (1—q) and q, respectively, while for the females the proportions are ($1-q^2$) normal and q^2 affected females. Indicating the observed proportions in these classes by A, B, C, and D, respectively, and replacing q by $\zeta/1-\zeta$, we have the following equations of estimation:

$$A=1-2\zeta/1-\zeta,\ B=\zeta/1-\zeta,\ C=1-2\zeta(1-\zeta)^2,\text{ and } D=\zeta^2/(1-\zeta)^2\ldots(1)$$

The probability of observing α normal and β affected individuals in a sample of N_1 males and of observing γ normal and δ affected individuals in a sample of N_2 females may therefore be written

$$P=\frac{N_1!N_2!}{\alpha!\beta!\gamma!\delta!}\left(\frac{1-2\zeta}{1-\zeta}\right)^{\alpha}\left(\frac{\zeta}{1-\zeta}\right)^{\beta}\left(\frac{1-2\zeta}{(1-\zeta)^2}\right)^{\gamma}\left(\frac{\zeta^2}{(1-\zeta)^2}\right)^{\delta},\ldots\ldots\ldots(2)$$

or
$$L=\log P=\log N_1!N_2!/\alpha!\beta!\gamma!\delta!+(\alpha+\gamma)\log(1-2\zeta)$$
$$+(\beta+2\delta)\log\zeta-(\alpha+\beta+2\gamma+2\delta)\log(1-\zeta)\ldots\ldots\ldots(3)$$

The optimum estimate of ζ from the observed N_1+N_2 individuals is obtained by employing Fisher's (1921) Method of Maximum Likelihood, which consists in finding the value of ζ for which L is maximum. Setting

$$\frac{dL}{d\zeta}=\frac{\alpha+\beta+2\gamma+2\delta}{1-\zeta}+\frac{\beta+2\delta}{\zeta}-\frac{2(\alpha+\gamma)}{1-2\zeta}=0\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

leads to a quadratic equation of which the positive root is the maximum likelihood estimate,

$$(\zeta)_1 = \frac{\sqrt{(\alpha+2\beta+4\delta)^2+8\gamma(\beta+2\delta)}-(\alpha+2\beta+4\delta)}{4\gamma} \quad \ldots\ldots\ldots\ldots (5)$$

The notation (ζ) is used throughout this note to indicate a particular estimate of the parameter ζ. This function, (5), though somewhat laborious to calculate is nevertheless to be preferred over other estimates of ζ, since the invariance or reciprocal of the variance of this statistic, which is the amount of information respecting ζ elicited by the likelihood statistic in the observation of N_1+N_2 individuals, is never exceeded by that of any other estimate. This property of maximum likelihood statistics, which Fisher has termed "efficiency," is very readily demonstrated for this problem. The amount of information respecting any parameter, ζ, furnished by a sample of N_1+N_2 individuals is given by

$$I_\zeta = S\left\{\frac{1}{m}\left(\frac{dm}{d\zeta}\right)^2\right\},$$

where m is the expected number in any class, the summation extending over all classes. The evaluation of this quantity for our problem may be presented in tabular form (Table II).

TABLE II

Expected Frequency, m	Differential coefficient, dm/dζ	$\frac{1}{m}\left(\frac{dm}{d\zeta}\right)^2$	
$N_1\frac{1-2\zeta}{1-\zeta}$	$-N_1\frac{1}{(1-\zeta)^2}$	$\frac{N_1}{(1-2\zeta)\ (1-\zeta)^3}$	$\frac{N_1}{\zeta\ (1-\zeta)^2\ (1-2\zeta)}$
$N_1\frac{\zeta}{1-\zeta}$	$N_1\frac{1}{(1-\zeta)^2}$	$\frac{N_1}{\zeta\ (1-\zeta)^3}$	
$N_2\frac{1-2\zeta}{(1-\zeta)^2}$	$-2N_2\frac{\zeta}{(1-\zeta)^3}$	$\frac{4N_2}{(1-2\zeta)\ (1-\zeta)^4}$	$\frac{4N_2}{(1-\zeta)^2\ (1-2\zeta)}$
$N_2\frac{\zeta^2}{(1-\zeta)^2}$	$2N_2\frac{\zeta}{(1-\zeta)^3}$	$\frac{4N_2}{(1-\zeta)^4}$	
$N_1 + N_2$	0		$I_\zeta = \frac{N_1 + 4N_2\zeta}{\zeta\ (1-\zeta)^2\ (1-2\zeta)}$

This quantity is in fact the amount of information utilized by the likelihood estimate $(\zeta)_1$, the variance of which is therefore

$$V(\zeta)_1 = \frac{\zeta(1-\zeta)^2(1-2\zeta)}{N_1+4N_2\zeta} \quad \text{.....................} (6)$$

Putting N_1 and N_2 each equal to unity, the amount of information provided by an observation of one male and one female is

$$i(\zeta)_1 = \frac{1+4\zeta}{\zeta(1-\zeta)^2\,(1-2\zeta)}.$$

Now from the observed proportions, A, B, C, and D, it is possible by employing the relations in (1) to invent innumerable estimates of ζ, and the sampling variance of each statistic, (ζ), may be derived by employing the formula,

$$\frac{1}{N}V(\zeta) = S\left\{w\left(\frac{\partial(\zeta)}{\partial\nu}\right)^2\right\} - \left(\frac{\partial(\zeta)}{\partial N}\right)^2,$$

in which w is the expected proportion in any class, and ν the observed number in that class. Each of the frequencies ν is replaced by the expectancy Nw after differentiation and the expressions for all classes are summed. By putting N_1 and N_2 each equal to unity in the reciprocal of the variance formula thus obtained we have the amount of information $i(\zeta)$ respecting ζ elicited by the estimate through the observation of one male and one female. By dividing the amount of information elicited by the amount available, $i(\zeta)_1$, we have the proportional amount of information utilized by the alternative statistic. This proportion is termed the relative efficiency of the estimate in question and may be designated by $E(\zeta)$. Below are listed some of these other estimates together with the corresponding values of $E(\zeta)$.

In estimating ζ we might utilize either the male proportions (A and B) or the female proportions (C and D) separately. Thus

$$(\zeta)_2 = \frac{B}{1+B} = \frac{\beta}{\alpha+2\beta}, \text{ and } E\,(\zeta)_2 = \frac{1}{1+4\zeta}.$$

$$(\zeta)_3 = \frac{\sqrt{D}}{1+\sqrt{D}} = \frac{\sqrt{\delta}}{\sqrt{\gamma+\delta}+\sqrt{\delta}}, \text{ and } E\,(\zeta)_3 = \frac{4}{1+4\zeta}.$$

The estimates $(\zeta)_2$ and $(\zeta)_3$ are based on males alone and on females alone. The effect of putting N_1 and N_2 equal to unity is to make $i(\zeta)_2$ and $i(\zeta)_3$ represent the amount of information per male and the amount per female, respectively. These values are compared with $i(\zeta)_1$, the information furnished by two individuals, one male and one female. $E(\zeta)_2$ and $E(\zeta)_3$ therefore give the proportional amounts of information used when equal numbers of both sexes are available but where females and males, respectively are disregarded in obtaining the estimate of ζ.

By averaging the two estimates thus derived we might obtain a fourth statistic,

$$(\zeta)_4=\frac{1}{2}\left(\frac{B}{1+B}+\frac{\sqrt{D}}{1+\sqrt{D}}\right)=\frac{\alpha\sqrt{\delta}+3\beta\sqrt{\delta}+\beta\sqrt{\gamma+\delta}}{2(\alpha+2\beta)\left(\sqrt{\gamma+\delta}+\sqrt{\delta}\right)},$$

$$\text{and E }(\zeta)_4=\frac{16\zeta}{(1+4\zeta)^2}$$

Some other estimates and their efficiencies are

$$(\zeta)_5=\frac{D(1-B)}{B(1-D)}=\frac{\alpha\delta}{\beta\gamma},\text{ and E }(\zeta)_5=\frac{\zeta(1-2\zeta)^2}{(1+4\zeta)\,(1-\zeta+\zeta^2)}.$$

$$(\zeta)_6=\frac{B-D}{1-D}=\frac{\beta\gamma-\alpha\delta}{\gamma(\alpha+\beta)},\text{ and E }(\zeta)_6=\frac{(1-2\zeta)^2}{(1+\zeta)\,(1+4\zeta)}.$$

$$(\zeta)_7=\frac{D}{B+D}=\frac{\delta(\alpha+\beta)}{\beta(\gamma+\delta)+\delta(\alpha+\beta)},\text{ and E }(\zeta)_7=\frac{1+\zeta}{1+4\zeta}.$$

The efficiency of each of the alternative estimates never exceeds unity and for many values of q the alternative estimates allow considerable loss of information. The values of the efficiencies of the alternative estimates in terms of per cent for values of q from 0 to 1 are shown in Figure 1.

SUMMARY

For a character attributable to a recessive autosomal gene substitution, the expected proportion of affected children among offspring of parents one of whom is affected is also $q/1+q$ or ζ, and the expected proportion of affected children among offspring of both normal parents is $(q/1+q)^2$ or ζ^2 (Snyder, 1934a). In terms of the gene-frequency, q, the proportion of affected individuals in the general population is the same as that for the female population with respect to a sex-linked recessive character and ζ is efficiently estimated as

$$(\zeta)=\sqrt{B'}/1+\sqrt{B'},$$

while

$$(\zeta^2)=B'/(1+\sqrt{B'})^2,$$

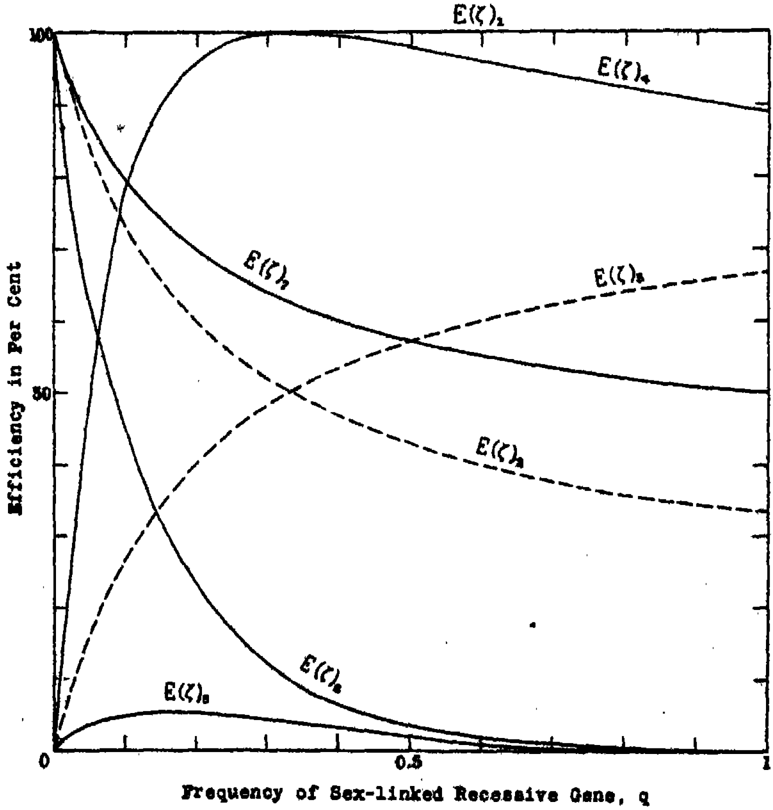

FIG. 1. The relative efficiencies of various estimates of the proportion ζ ($=q/1+q$) for a sex-linked recessive gene substitution. The top line, E $(\zeta)_1$, indicates that the likelihood estimate uses the whole of the available amount of information for all values of q.

where B' is the observed proportion of affected individuals in the general population. The variance of these proportions, however, may be written in somewhat simpler form than the formulae given by Snyder. As is shown in Table II, the variance of ζ is

$$V(\zeta) = \frac{(1-2\zeta)\,(1-\zeta)^2}{4N},$$

in which N is the total number of individuals in the sample. The variance of ζ^2 is readily derived by means of the transformation formula,

$$I\zeta^2 = \left(\frac{d\zeta}{d\zeta^2}\right)^2 I\zeta = \frac{1}{4\zeta^2}\,I\zeta.$$

Hence $$V(\zeta^2) = 4\zeta^2 \,.\, V(\zeta).$$

Employing these formulae the values of $V(\zeta)/N$ and $V(\zeta^2)/N$ for values of B' from 0 to 1 might readily be added to the tables of ζ and ζ^2 already given by Snyder, thus further simplifying calculations.

For a sex-linked recessive character, ζ is the proportion of affected individuals to be expected among children of normal mothers and affected fathers as well as the expected proportion of affected sons where parents are both normal. The problem of estimating ζ for a sex-linked character is, however, a somewhat more difficult task arithmetically, the optimum estimate and its sampling variance being obtained by means of equations (5) and (6) of this note.

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AN EXPERIMENT WITH HEAVY WATER

JOHN S. RICHARDSON
AND
G. RAYMOND HOOD[1]

In connection with a study of the chemistry of deuterium, we have had occasion in this laboratory to investigate the reaction of carbon dioxide on sodium carbonate dissolved in water containing 0.162% deuterium oxide. Possible reactions may be formulated as:[2]

1) $H_2O+D_2O+Na_2CO_3+CO_2 \longrightarrow NaHCO_3$ (preferentially)
2) $H_2O+D_2O+Na_2CO_3+CO_2 \longrightarrow NaDCO_3$ (preferentially)
3) $H_2O+H_2\mathbf{O}+Na_2CO_3+CO_2 \longrightarrow NaHCO_3$ (preferentially)
4) $H_2O+H_2\mathbf{O}+Na_2CO_3+CO_2 \longrightarrow NaHC\mathbf{O}_3$ (preferentially)

Equations (2) and (4) will yield a product which on thermal decomposition should give sodium carbonate, carbon dioxide, and a water of greater density than that taken for the synthesis of the bicarbonate; while a purely chance distribution of the light and heavy isotopes of hydrogen and oxygen, or a particular combination of equations (1) and (4), should result in a bicarbonate which would yield a water having the same density as that used for the synthesis.

EXPERIMENTAL

A sample of commercial "electrolytic water" containing 0.05% of deuterium oxide was further concentrated by electrolysis until its specific gravity with respect to ordinary water was 1.0001751 (at 25° C.), according to quadruplicate determinations made with two separately purified samples, and using two floats. Our float equilibrium temperatures were determined by the method of Emelius *et al.* (1)

A sample of 180 cc. of this water was saturated with anhydrous Na_2CO_3 (Merck Reagent) and placed in a closed reaction vessel agitated by rocking. Tank carbon dioxide was scrubbed with sulfuric acid, passed through glass wool, a tower of anhydrous magnesium perchlorate, and then over the sodium carbonate solution; the excess gas escaping to the atmosphere through another drying tower. Passage of the gas was continued for 48 hours. About 50 g. of $NaHCO_3$ precipitated and was separated by filtration; the precipitate was dried for 10 hours in vacuo over sulfuric acid; and then was decomposed by heating in a pyrex tube. It yielded 7.545 g. of water, weighed after purification by redistillation. As this was too small a sample for a density determination, it was mixed with 17.019 g. of ordinary water (previously thrice distilled) and the specific gravity of the mixture with respect to ordinary water was determined as 1.0000536 in duplicate determinations; the mixed sample being again redistilled between the two density measurements. Assuming that the volumes of the two water samples are additive, the density of the water recovered by decomposition of the bicarbonate must have had a specific gravity with respect to ordinary water of 1.0001829.

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[1] Contribution from the chemical laboratory of Miami University.

[2] The symbol **O** referring to the heavy isotope, O^{18}.

The filtrate from the precipitated bicarbonate was distilled from the residue remaining upon its evaporation, and twice redistilled; approximately 150 cc. was recovered after purification. Density determinations were then made upon it, using two floats; the sample was again distilled, and the density determinations were again carried out. The specific gravity with respect to ordinary water was 1.0001699.

The equilibrium temperatures for the floats used are recorded below, the temperatures being read from a Beckmann thermometer calibrated against a Centigrade thermometer certified by the Bureau of Standards.

Equilibrium temperature for Float:	No. I	No. II
Redistilled common water (Expt. 1)	24.539°	24.827°
" " " (Expt. 2)	24.538	24.828
Redistilled heavy water (Expt. 1)	25.220	25.503
" " " (Expt. 2)	25.218	25.506
Recovered filtrate water (Expt. 1)	25.198	25.481
" " " (Expt. 2)	25.198	25.490
Diluted water from $NaHCO_3$ (Expt. 1)	24.746	......
" " " " (Expt. 2)	24.751	......

These temperatures indicate that if the specific gravity of ordinary water is taken as unity at the equilibrium temperature, we have for:

	Specific gravity	% D_2O
Heavy water taken for the experiment	1.0001751	0.162
Heavy water recovered from filtrate	1.0001699	0.157
Heavy water recovered from bicarbonate	1.0001829	0.169

DISCUSSION

These experiments indicate that a slight concentration of deuterium or of a heavy oxygen isotope occurs in the formation of sodium bicarbonate. The probability is that $\mathbf{O}$ is concentrated, as Urey and Greiff (2) have recently shown the fractionation:

$$2\,H_2\mathbf{O}+CO_2 \longrightarrow 2\,H_2O+C\mathbf{O}_2$$

while from a consideration of the speed with which ionogen equilibria are established we should be led to expect a purely chance distribution of $NaHCO_3$ and $NaDCO_3$ molecules; the concentration of $NaDCO_3$ being in direct ratio to the concentration of D_2O in the solution water.

REFERENCES CITED

(1) **Emelius, James, King, Pearson, Purcell, and Briscoe.** J. Chem. Soc., (1934), 1948.
(2) **Urey and Greiff.** J. Am. Chem. Soc., 57, 321 (1935).

Matter

In this volume the authors have discussed, almost entirely from a classical point of view, a selected number of subjects of interest in modern physics. The acceleration due to gravity, elasticity, compressibility of solids and liquids, surface phenomena and kinetic theory are among the topics to receive a comprehensive theoretical treatment which is subsequently made use of in the discussion of related experiments. A very interesting section is Chapter X on osmotic pressure in which a discussion is contained of the Debye-Hückel theory of strong electrolytes.

While the discussions and derivations are complete and adequate, involved mathematics is not resorted to and the book should find a strong clientele among intermediate students. The book may be sincerely recommended and merits its place as one of the new Prentice-Hall series.—H. NIELSON.

Properties of Matter, by F. C. Champion and N. Davey. vii+287 pp. New York, Prentice-Hall, Inc., 1936. $4.50.

How We Came by Our Bodies

According to the author's statement in the introduction, this book is intended to increase the interest of the lay reader in reproduction, as well as to summarize some of the recent advances in the fields of Embryology and Genetics. The material is presented under three main headings: Part I, The Course of Development; Part II, The Machinery of Development; Part III, History of the Origin of the Machinery of Development.

Parts II and III present a very readable summary of the work of Genetics, though there is considerable doubt as to whether the average lay reader would get a very clear picture of the field. The cell and its chemical processes are summarized. The nature and activity of the gene are discussed. The effect of the cytoplasm in regulating development is reviewed, followed by a short discussion of histogenesis. Part II is concluded with a chapter on abnormalities of development. Part III is concerned with somewhat diverse topics. The possible derivation of the gene is traced through Bacteriophage, Virus, Bacterium, Yeast and Protozoan. A chapter is given to mutations in genes and the effect on the organism. A final chapter contains a bird's eye view of the evolutionary history of man and his possibilities in the future.

Part I, The Course of Development, summarizes the embryological development of the child. The treatment of this portion of the material, however, is so teleological that numerous erroneous impressions are left with the reader, viz., "And so, before the sperm cell enters the egg, the egg casts out the equivalent of what the sperm brings in." In another place this sentence is found, "This is all in accordance with the principle that the child develops with reference to future needs, and not with reference to current ones." Had the first six chapters (Part I) been omitted, the book would have been more acceptable.

The volume is profusely illustrated, though some of the plates are so technical that they could have little meaning for the average layman. The printing is excellent and the paper of good quality.—PAUL E. SCHAEFER.

How We Came by Our Bodies, by C. B. Davenport. xii+401 pp. New York, Henry Holt and Company, Inc., 1936. $3.00.

A STUDY OF THE LEECHES OF MICHIGAN

WITH KEY TO ORDERS, SUBORDERS AND SPECIES

JOHN A. MILLER
Ohio State University

The leeches referred to in this study were collected in the state of Michigan in 1925, 1926, and 1927 by Dr. Y. Metzelaar and assistants of the University of Michigan. They were secured for study from the Museum of Zoology through the courtesy of Dr. Carl Hubbs of the University of Michigan and Dr. Raymond C. Osburn of the Ohio State University.

CONSPECTUS OF THE LEECHES OF MICHIGAN

ORDER 1. RHYNCHOBDELLA
  FAMILY GLOSSIPHONIDAE
    Genus *Glossiphonia*, Johnston, 1816.
      Glossiphonia stagnalis (Linnaeus) 1758.
      Glossiphonia complanata (Linnaeus) 1758.
    Genus *Placobdella*, Blanchard, 1893.
      Placobdella montifera Moore, 1912.
      Placobdella parasitica (Say) 1824.
      Placobdella picta (Verrill) 1872.
      Placobdella rugosa (Verrill) 1874.

ORDER 2. ARHYNCHOBDELLA
  SUBORDER 1. GNATHOBDELLA
  FAMILY HIRUDINIDAE
    Genus *Macrobdella*, Verrill, 1872.
      Macrobdella decora (Say) 1824.
    Genus *Haemopis*, Savigny, 1874.
      Haemopis marmoratis (Say) 1824.
      Haemopis lateralis (Say) 1824.
      Haemopis plumbeus Moore 1912.
      Haemopis grandis (Verrill) 1874.
  SUBORDER 2. HERPOBDELLIDA
  FAMILY HERPOBDELLIDAE
    Genus *Herpobdella*, Blainville.
      Herpobdella punctata (Leidy) 1870.
    Genus *Dina*, Blanchard.
      Dina fervida (Verrill) 1871.

KEY TO THE ORDERS AND SUB-ORDERS

ORDER 1. RHYNCHOBDELLA.

The mouth is a small pore in the anterior sucker, from which a muscular proboscis can be protruded and retracted. No jaws present. Two families, Glossiphonidae taken in this collection and Icthyobdellidae not found in this collection but previously reported in other collections. (1A to II in key).

ORDER 2. ARHYNCHOBDELLA.

No proboscis present. This order includes two suborders:

SUBORDER 1. GNATHOBDELLA.

A large mouth usually with toothed jaws, pharynx not forming a protrusible proboscis. This suborder includes one family, Hirudinidae (11 to 2A).

SUBORDER 2. HERPOBDELLIDA.

Mouth medium, not armed with true jaws. No gastric caeca. Habits predaceous. This suborder includes one family, Herpobdellidae (2A in key).

ARTIFICIAL KEY TO SPECIES IN COLLECTION

1. Mouth a small pore in the anterior sucker, from which a muscular probosis can be protruded; no jaws.
  - 1A. Complete somites essentially triannulate.
    - 1a. Eyes one pair, distinct, not contiguous in middle line. Genital pores separated by one annulus.
      - 1b. A conspicuous dark brown cuticular plate and gland on the dorsum. Color: Pale pink, grayish or brownish.......... **Glossiphonia stagnalis**
    - 2a. Eyes in several pairs. Genital pores separated by two annuli.
      - 1b. Eyes in three pairs in nearly parallel rows. Seven pairs of gastric caeca. Nine pairs of testes. Body with a pair of dark longitudinal lines, above and below. Color: Brownish green with flecked dorsum. Body moderately thick and deeply pigmented, **Glossiphonia complanata**
    - 3a. Eyes one pair, compound. Seven pairs of branched gastric caeca. Side moderate to large.
      - 1b. Anterior somites widened to form discoid head.
        - 1c. Dorsum marked with three strongly papillated keels. Gastric caeca much branched. Color: Greenish brown, yellow marginal spots.. **Placobdella montifera**
      - 2b. Anterior somites not widened to form discoid head.
        - 1c. Body broad and flat, anterior sucker fused, posterior sucker free and distinct. Dorsal papillae few. Color: Pattern variable. Body green with yellow head, triangular reddish brown marginal spots, ventral surface striped.................. **Placobdella parasitica**
        - 2c. Body smooth, much depressed, broad posteriorly, somewhat tapering anteriorly. Ocular region surrounded by triangular white area. Color: Dark brownish green, finely variegated with orange; a row of semicircular orange spots along the margin, **Placobdella picta**
        - 3c. Body much depressed. Dorsal papillae numerous, variable in conspicuousness, though usually rough and high. Median row forms a conspicuous interrupted line. Color: A mixture of browns, greens and yellows.............................. **Placobdella rugosa**

II. No proboscis. Mouth large, occupying entire cavity of the oral sucker.
  - 1A. Eyes five pairs on somites two to six, arranged in a submarginal arc. Genital ducts complex, muscular protrusible penis usually present. Testes paired, usually nine or ten pairs. Stomach provided with gastric caeca.

1a. Jaws prominent, teeth numerous, in one series, caeca along entire stomach.
  1b. Genital orifices separated by five annuli. Dorsum with metameric, median red and marginal black spots..............**Macrobdella decora**
2a. Jaws small, provided with few teeth. Genital orifices separated by five annuli.
  1b. Twelve to sixteen pairs of teeth on each jaw. Color: Variable, usually non-metamerically blotched with black..**Haemopis marmoratis**
  2b. Twenty to twenty-five pairs of teeth on each jaw. Color: Uniform dark olive green, a dark median longitudinal stripe, a paler marginal stripe, often approaching a buff. Few or no blotches, **Haemopis lateralis**
3a. Jaws absent, no teeth present.
  1b. Lip broad and flat. Few dorsal blotches or entirely wanting. No ventral blotches. Color: Uniform plumbeous or slaty-gray. Along the entire lateral margin there is a conspicuous rufous or orange band..**Haemopis plumbeous**
  2b. Lips thin, mouth moderate, caudal sucker round, broadly attached, slightly cupped. Male orifice at XI-b^5/b^6, female orifice at XII-b^5/b^6. Ovaries in somite XII. Size large, inhabits borders of bodies of water. Color: (Preserved) plumbeous, slaty black, no conspicuous marks. (According to Moore, protruded penis slender and straight, ground color paler than dorsal, dark blotches present), **Haemopis grandis**

2A. Eyes three or four pairs, not arranged in a regular arch. One or two pairs on somite two, and two pairs on the sides of the mouth on somite four. No jaws, no gastric caeca. Testes numerous, not paired. Predaceous.
  1a. Eyes three pairs, first pair largest. Body elongate, sides nearly parallel. Color: Brownish gray, margin tinted red by lateral blood vessels. Rows of black spots arranged irregularly on dorsum, **Herpobdella punctata**
  2a. Eyes usually three pairs. Body depressed posteriorly, rounded anteriorly. Large caudal sucker. Color: A dusky reddish brown, dorsum marked with double row of black spots. Genital pores separated by two annuli..................................**Dina fervida**

RECORD OF DISTRIBUTION

Glossiphonia stagnalis (Linnaeus) 1758.
  Flint Creek, Hubbs and Schultz, 1926.

Glossiphonia complanata (Linnaeus) 1758.
  Osego Lake, Metzelaar, Aug. 23, 1925.
  Hunt Creek, Metzelaar and Langlois, July 17, 1925.
  Pool, Mecosshe Co., 7 mm. Metzelaar, June 11, 1925.
  Sucker River, Luce Co., 81 mm. Metzelaar and Langlois, June 19, 1925.
  Spectacle Lake, 6 mm. Metzelaar and Langlois, June 18, 1925.

Placobdella montifera Moore 1912.
  Cheboygan Co., Indian River, 2 mm. Metzelaar and Langlois, June 14, 1925.

Placobdella parasitica (Say) 1824.
  Dog Lake, Cheboygan Co., 3 mm. Metzelaar, August 12, 1925.
  North Twin Lake, Cheboygan Co., 2 mm. Metzelaar and Langlois, August, 1925.
  Raisin River, Langlois, May 12, 1927.
  Stony Lake, Jackson Co., Metzelaar, June, 1926.
  Long Lake, 2 mm. Metzelaar and Langlois, July 23, 1925.
  *Pere Marquette River, Lake Co., 5 cm. (with 12 young), Metzelaar, March 15, 1925.
  Dollar Pond, near Black River, Cheboygan Co., 3.5 cm. Metzelaar and Langlois, August 13, 1925.

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*Note the dates at which *Placobdella parasitica* was taken with young attached.

Placobdella parasitica [Continued]

Avery Lake, Thunder Bay River, drainage, Montmorency Co., 2.5 cm. Metzelaar and Langlois, July 8, 1925.

Newago Co., Langlois and Moody.

*S-Lake, Montmorency Co., 3 cm. with young, Metzelaar and Langlois, July 22, 1925.

Sucker River, Luce Co., 2.5 cm. Metzelaar and Langlois, June 19, 1925.

Placobdella picta (Verrill) 1872.

Bunners Creek, 1926.

Placobdella rugosa (Verrill) 1874.

Big South Branch, Pere Marquette, Newago Co., 2.8 mm. Metzelaar and Langlois, July 22, 1926.

Luce Co., Pike Lake Forest Reserve, Langlois and Metzelaar, June 18, 1925.

Valentine Lake, Montmorency Co., 1.5 mm. Metzelaar and Langlois, July 5, 1925.

Pickeral Creek, near P. Lake, Newaygo Co., 3 cm. with young, Langlois and Moody, July 7, 1926.

Bass Lake, Metzelaar, May 12, 1926.

Station 120, Metzelaar, 1925.

Newago Lake, Langlois and Moody.

Loockwood Lake, Montmorency Co., Langlois and Metzelaar, July 14, 1927.

Northern Tomohawk Lake, Montmorency Co., Metzelaar and Langlois, July 13, 1925.

S-Lake, Montmorency Co., 3 cm. Metzelaar and Langlois, July 22, 1925.

Sucker River, Luce Co., Metzelaar and Langlois, June 19, 1925.

Fremont Creek, 1.9 cm. Moody and Langlois.

Macrobdella decora (Say) 1824.

Thomas Lake, Osego Co., Metzelaar, 6 mm., August 24, 1925.

S-Lakes, N. W. of Gaylord, Osego Co., 5 cm. Metzelaar, Aug. 16, 1925.

Valentine Lake, Montmorency Co., July 5, 1925.

Haemopis marmoratis (Say) 1824.

Pike Lake, Forest Reserve, Luce Co., 4.5 cm. Metzelaar and Langlois, June 18, 1925.

Hagar Lake, Metzelaar and Langlois.

Muddy Creek (120) Metzelaar, 1925.

Head of Boardman Lake, Traverne Co., Metzelaar, May 13, 1925.

Cress Brook, Metzelaar, 1925.

Back Water, Muskegon River, Metzelaar.

Luce Co., 5.5 cm. Metzelaar, May 25, 1925.

Haemopis laterallis (Say) 1824.

Clam Creek, 6 cm. Metzelaar, May 13, 1926.

Creek in Kent Co., Metzelaar, 1927.

Haemopis plumbeous Moore 1912.

Vicinity of Perch Lake, Lake Superior Forest Reserve, Metzelaar and Langlois, June 15, 1925.

Lac Viene, Wisconsin and Michigan border, Metzelaar and Langlois.

Thunder Bay River (Bass Lake), Metzelaar.

Forest Reserve, Luce Co., Metzelaar and Langlois, June 18, 1925.

Haemopis grandis (Verrill) 1874.

Luce Co., Metzelaar, May 25, 1925.

Vicinity Perch Lake, Lake Superior Forest Reserve, Metzelaar and Langlois, June 15, 1925.

Muskegon drainage, Grant Township, 5 cm. Metzelaar, May 9, 1925.

Lake Superior Forest Reserve, 4 cm., June 15, 1925.

Balloger Creek, Metzelaar.

Forest Reserve, Luce Co., June 18, 1925.

Canada Creek, 4.5 cm., June 18, 1925.

Herpobdella punctata (Leidy) 1870.

Indian River, 8 mm. Langlois, June 14, 1925.

Luce Co., Metzelaar, May 25, 1925.

Bass Lake (Sta. 410), 6.5 cm. Metzelaar, May 22, 1926.

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*See note page 87.

Herpobdella punctata [Continued]
Dickerson Lake, Metzelaar and Langlois, Oct. 5, 1925.
Gull Lake, H. W. Fowler, 1925.
Tributary Maple Creek, Hubbs and Langlois, 1925.
Thunder Bay River (Bass Lake), Metzelaar and Langlois, 1925.
Pere Marquette River, Lake Co., Metzelaar.
Head Waters of Perch Lake, 5 cm. Metzelaar and Langlois.
Baker Creek, Neweygo Co., Langlois and Mosley, July 12, 1926.
Lake Co., Metzelaar, March 23, 1925.
Newaygo Co., 5 cm. Langlois and Mosley, July 10, 1926.
Lac Viene, Wisconsin and Michigan border, Metzelaar and Langois, Sept. 21, 1925.
Pere Marquette River, Metzelaar, 1925.
Dina Fervida (Verrill) 1871.
Creek Tributary to Pere Marquette River, Lake Co., Metzelaar, April 23, 1926.

The following list of species occurred in the collection taken from the state of Wisconsin:

Glossiphonia nepheloidae (Graff) 1899.
Lake 6 mi. S. W. of Dixon, Columbia Co., Green and Jones, Aug. 24, 1925.
Macrobdella decora (Say) 1824.
Wabekon Lake, Forest Co., H. T. Bolger, 6 cm.
Haemopis plumbeus Moore 1912.
Trout Stream, Riley Lake, Forest Co., 2.5 cm. H. T. Folger.
Haemopis grandis (Verrill) 1874.
Oconte and Rat River, Forest Co., 5 cm. H. T. Folger, Sept. 1, 1925.
Herpobdella punctata (Leidy) 1870.
Madelin Lake, Oneda Co., Metzelaar and Langois, Sept. 19, 1925.

CONCLUSION

In concluding this report I wish to state that this, though not complete, is a fair estimate of the leeches to be found in the State of Michigan. The leeches examined were in no essential features different from those found in other of the North, Central and Eastern States.

The leeches of this collection were, for the most part, in a coiled or contracted state making measurements mean but little. It was particularly evident from the collection that the Genus *Haemopis* was in abundance, four species being recorded. This may have been due to their large size and slow moving habits. It was interesting to note that *Placobdella parasitica* was carrying young as early as March 15th, and as late as July 22nd. This tends to substantiate the theory of a number of broods in a season.

A table of the known food habits of the leeches of Ohio is included in this report. There is reason to believe that the Michigan forms would follow essentially the same food habits as Ohio species.

The value of this study is in the knowledge it affords of the occurrence and distribution of Michigan leeches.

TABLE I
The Food of Leeches of Ohio

	Turtle	Fish	Snail	Aquatic annelid	Earthworm	Insect larvae	Organic debris	Mammals	Frogs	Scavengers
Glossiphonia stagnalis		x	x	x		x		x	x	x
Glossiphonia nepheloidea		x	x	x			x			x
Glossiphonia fusca		x	x	x		x				
Glossiphonia complanata			x	x						
Placobdella montifera		x	x					x	x	
Placobdella parasitica	x			x						
Placobdella rugosa	x		x							
Placobdella picta	Unknown									
Placobdella phalera	Unknown									
Actinobdella inequiannulata	Unknown									
Piscicola punctata		x								
Macrobdella decora	x	x		x				x	x	
Haemopis grandis			x	x	x	x	x			x
Haemopis marmoratis				x	x	x	x	x		x
Haemopis lateralis				x	x	x		x		
Haemopis plumbeus					x		x			
Herpobdella punctata			x	x		x		x	x	
Dina microstoma				x						
Dina fervida				x		x				

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THE DAILY RATE OF GROWTH OF TOE NAILS

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INTRODUCTION

It is generally known that nail growth is often retarded in acute infectious diseases, such as various fevers. However, no work has been published concerning the quantitative effect of disease and other nutritional disturbances, such for example, as pregnancy and hyperthyroidism, on the rate of nail growth. Such a study is now in progress and a prerequisite step to this project was the determination of the normal rate of nail growth in healthy individuals.

Several workers, notably Berthold ('50), Dufour ('72), Heller ('00), Voit ('30) and Sharpey-Schäfer ('30), have studied the rate of growth of finger nails and although different methods of measurement were employed it is generally agreed that normally the growth is on the average of one millimeter in ten days, that is 0.100 mm. daily. Results of observations made by the writers on the daily rate of finger nail growth in a great number of normal, healthy subjects agree in general with this figure. As regard the rate of toe nail growth, however, a review of the literature has failed to reveal any published data. Since the need for such information was felt in connection with the problem concerning the effect of disease on the rate of nail growth, accordingly research was started in an attempt to supply it. The object of this paper, therefore, is to report the results of observations made on the daily rate of toe nail growth in 70 apparently normal, healthy subjects of both sexes, ranging in age from 3 to 65 years.

It has been found by several of the above mentioned investigators that numerous factors affect the rate of growth of finger nails. Thus according to Berthold they grow more rapidly in summer than in winter, in children than in adults and slowest in old age; that normally those on the right hand grow more rapidly than those on the left and most rapidly on the longest fingers and slowest on the thumbs. In view of these findings of Berthold et al it was also decided to investigate some of these factors with respect to toe nails. The 70 subjects were therefore subdivided into groups according to sex (33 males and 37 females) and age. Age groupings were arbitrarily made; children (20) including those up to the age of 15 years; youths (30) those from 16 to 25 years, and adults (20) all those 26 years or older. Comparison of the mean rates of toe nail growth of these groups as well as those of the various toes was made in order to determine whether or not there is any significant variation. The technique of analysis of variance was applied to the sample as a means of procedure. This directly brings out the elements that may be contributing to disturbed homogeneity.

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METHODS

A mark was made on each toe nail by means of a sharp, curved scalpel. In the case of the great toe nails the mark was made at the distal central convex line of the lunula, whereas, on the remaining toe nails, from which a lunula is almost invariably absent, it was made at a determined distance, usually five millimeters, proximal to the anterior central border of the nail bed. The amount of growth exhibited by the great toe nails was determined by measuring the distance which the mark traversed from the anterior margin of the lunula, while in the case of the other toe nails it was calculated by subtracting the distance between the mark and the anterior border of the nail bed from the distance between the latter point and the mark used as a measuring point. Thus if the mark was made at a point 5 mm. from the anterior border of the nail bed and at a later date it was 3.5 mm. from the latter point the amount of growth would be (5 mm. minus 3.5 mm.) 1.5 mm.

The daily rate of growth of the nail was ascertained by dividing the amount of growth by the number of days of growth. Thus let us suppose that in 30 days of growth the distance of the mark from the lunula on the great toe nail was 1.5 mm. The daily rate of growth in this case would be (1.5 mm. divided by 30 days) 0.05 mm. For the other toe nails the method of calculation would be the same, that is (5 mm. minus 3.5 mm.) 1.5 mm. divided by 30 days (0.05 mm.).

All measurements were made by means of a Vernier caliper calibrated in millimeters, the two measuring arms of which were sharpened in order to insure a fine degree of accuracy. All marks on the nails as well as the adjustments of the measuring arms of the Vernier to these marks were made under magnification with the use of a binocular loupé.

RESULTS

In Table I are listed the data for the 70 subjects including the daily rate of growth of each toe nail (indicated as R and L 1–5, respectively), the age, sex and mean daily rate of nail growth for each subject and for each nail. The figures indicating the rates of nail growth represent thousandths of a millimeter. Thus in subject H. A., for example, the

TABLE I

Daily Rate of Growth of Toe Nails

Seventy Subjects

Subject	R1	2	3	4	5	L1	2	3	4	5	Age	Sex	M
H. A.	61	37	50	50	50	61	50	48	37	50	8	M	49.4
P. B.	52	56	48	50	50	53	48	57	48	32	20	M	49.4
P. B.	72	33	66	66	50	55	66	50	83	45	22	M	58.6
H. B.	50	20	10	50	52	27	35	20	19	51	20	M	33.4
M. B.	50	50	50	50	50	66	30	50	66	45	15	F	50.7
B. B.	56	50	50	50	66	55	33	53	66	53	10	F	53.2
E. B.	50	46	25	50	75	90	75	50	48	50	35	M	55.9
H. B.	50	50	50	50	50	66	50	50	50	50	39	F	51.6
I. B.	56	56	56	56	31	56	56	56	56	31	41	F	51.0
B. B.	66	50	66	66	50	66	50	66	66	45	14	M	59.1
R. B.	66	50	50	83	83	66	50	50	50	45	44	M	59.3
T. B.	70	58	58	60	50	60	59	30	40	45	25	F	53.0
J. C.	56	50	50	50	50	85	50	50	50	50	5	M	54.1
B. C.	75	50	50	50	50	75	62	50	50	50	8	F	56.2
P. C.	75	62	50	50	50	50	62	50	50	50	3	F	54.9
M. C.	62	50	50	37	37	62	50	37	37	50	10	F	47.2
V. C.	75	75	75	50	50	55	50	50	50	50	32	F	58.0
J. C.	62	50	50	50	50	62	50	50	50	50	6	F	52.4
I. D.	50	33	40	30	50	46	50	50	50	45	15	F	44.4
M. D.	66	40	50	33	50	50	50	50	50	50	26	M	48.9
L. E.	50	50	50	50	50	50	50	50	50	45	34	M	49.5
A. E.	57	57	57	57	57	57	57	57	57	57	58	M	57.0
F. E.	57	57	57	50	50	57	57	57	48	45	28	F	53.5
E. E.	50	50	50	50	50	66	50	50	50	66	28	F	53.2
A. E.	56	50	57	50	50	57	57	57	48	45	55	F	52.7
M. E.	56	50	25	25	50	75	75	25	48	45	62	F	47.4
B. E.	60	60	60	60	60	70	50	30	70	45	19	F	56.5
L. G.	66	59	48	58	39	64	63	48	32	42	20	M	51.9
J. G.	70	50	50	50	50	55	50	50	50	50	6	F	52.5
C. G.	62	50	50	50	50	62	50	50	50	50	8	F	52.4
A. H.	50	50	48	83	50	30	66	56	66	50	26	M	54.9
M. H.	50	50	50	50	50	50	50	50	50	50	30	F	50.0
L. H.	66	40	53	36	43	66	50	50	53	40	6	F	49.7
J. H.	37	25	25	25	50	37	37	37	50	45	65	F	36.8
R. J.	50	66	66	66	83	50	66	66	83	66	23	M	66.2
G. K.	66	45	45	66	66	45	66	66	45	30	25	F	54.0
W. K.	58	27	33	40	26	49	39	36	43	45	21	M	39.6
H. K.	50	33	29	38	50	48	48	38	46	36	19	F	41.6
G. K.	58	49	69	42	40	52	42	58	50	45	20	M	50.5
M. K.	40	57	40	38	50	55	57	57	56	45	19	F	49.5
H. L.	59	54	38	14	40	51	40	35	48	45	20	M	42.4
M. L.	60	53	53	73	83	58	53	62	62	73	20	M	63.0
B. L.	44	32	44	56	47	36	42	47	53	42	18	F	44.3
S. M.	35	50	50	50	35	35	50	50	50	25	20	F	43.0
B. M.	50	51	50	50	25	50	50	50	51	25	21	F	45.2
E. M.	86	40	65	65	65	65	50	50	50	25	19	F	56.1
E. M.	60	30	30	30	30	75	30	60	30	30	21	M	40.5

TABLE I—[*Continued*]

Subject	R1	2	3	4	5	L1	2	3	4	5	Age	sex	M
L. M.......	46	28	40	50	50	36	41	54	33	45	19	F	42.3
H. M.......	48	26	35	50	50	47	58	58	58	29	30	M	45.9
P. M.......	75	50	50	50	37	75	62	37	50	37	19	F	52.8
H. P.......	43	33	40	59	33	50	50	50	50	40	16	F	44.8
R. P.......	66	66	66	66	50	73	66	50	66	66	14	F	63.5
B. P.......	33	50	33	33	50	50	33	50	33	33	10	F	39.8
D. R.......	34	34	44	48	44	48	50	50	50	48	16	F	45.0
S. R.......	75	55	55	65	25	50	65	60	65	25	19	M	54.0
J. R.......	77	44	46	81	50	74	38	55	48	45	22	M	55.8
H. S.......	40	40	40	40	40	40	40	40	40	40	60	F	40.0
A. S.......	56	45	45	45	45	45	30	45	30	45	59	M	43.1
H. S.......	90	46	30	53	50	55	18	23	30	45	84	M	44.0
W. S.......	66	50	66	33	50	40	33	33	50	66	30	F	48.7
M. S.......	47	37	53	54	50	50	24	45	54	60	21	F	47.4
H. S.......	50	50	53	50	83	50	50	50	40	50	8	M	52.6
J. S.......	40	32	52	50	50	47	38	38	57	35	22	M	43.9
R. S.......	47	53	67	70	50	46	36	60	49	40	22	M	51.8
M. W.......	52	38	38	45	38	56	38	47	46	52	28	M	44.9
D. W.......	40	66	66	66	66	66	33	40	46	50	4	M	53.9
D. W.......	50	50	50	50	50	66	66	66	66	66	7	M	58.0
D. W.......	65	45	40	60	60	75	25	48	20	45	24	M	48.3
R. Y.......	50	50	50	50	50	50	50	50	50	50	3	M	50.0
P. Y.......	50	33	60	33	50	83	33	50	50	33	6	M	42.5
Means...	56.6	46.7	48.6	50.7	50.0	55.6	48.5	48.6	49.7	45.5			50.1

daily rate of growth of the great toe nails (R and L 1) is 61 thousandths of a millimeter each, which should be translated to read 0.061 mm. and the mean rate of growth of all his toe nails (49.4 thousandths of a millimeter) as 0.0494 mm.

The mean daily rate of growth of each nail is shown in the last horizontal line of figures at the bottom of the table, each figure representing the mean daily rate of growth of 70 toe nails. The last figure (50.1) on this horizontal line is the mean daily rate of growth of all the toe nails of the whole group, that is, of 700 toe nails (70 subjects × 10 toe nails). The mean daily rate of growth per toe nail then can be stated as .050 mm. with its standard error ± .0046.

Since the rate of growth of toe nails in relation to that of finger nails in healthy individuals is a pertinent question, the average rate of toe nail growth can be said in general to be approximately half that of the finger nails, that is .050 mm. for toe nails as to .100 mm. for finger nails.

However, the whole set of observations on the rate of growth of toe nails can not be considered as strictly homogeneous, since there is considerable variation from toe to toe and from individual to individual. If these variations are subjected to analysis of variance (Snedecor, '34) several interesting features regarding their source are brought out. From the figures given in Table II the homogeneity of the several toe means is examined by the ratio of the greater mean square to the lesser mean square. Designating this ratio by F,

$$F = \frac{\text{large mean square (869.95)}}{\text{smaller mean square (106.87)}} = 8.14$$

When this F ratio is referred to the table for an expression of the probability (Snedecor, pp. 88–91) it is found that the F of 8.14 lies beyond the 1% range expressed by an F of 2.55. That is, any variation as great as that observed would be expected to occur less than once per hundred samples if random variation alone were the sole source of differences.

TABLE II

ANALYSIS OF VARIANCE BETWEEN TOES AND INDIVIDUALS

Source of Variation	Degrees Freedom	Sum of Squares	Mean Square	Standard Deviation
Total	699	103,171.80		
Between Means of Toes	9	7,829.56	869.95	
Between Means of Individuals	69	28,977.50	419.96	
Remainder	621	66,364.74	106.87	10.3380

In order to determine which toe nails differ significantly in their rate of daily growth the standard error of difference between toe means was calculated as follows:

$$\sqrt{\frac{(106.87)\ (2)}{70}} = \sqrt{3.0534} = 1.7474 \text{ thousandths of 1 mm.}$$

Corresponding to the 5% point for 500 degrees of freedom, the value of t = 1.965 (table XXXV, Snedecor). Therefore, the least mean difference that can be considered significant is (1.965) (1.7474) = 3.434 thousandths of 1 mm.

Any difference between any two toe means, listed in Table III, that is greater than 3.434 thousandths of 1 mm. can be taken as indicative of a real difference. Reading the table for complete comparisons it is evident that the rate of growth of the great toe nails is distinct from the rates of the others. In general, the nails of the 2nd, 3rd, 4th and 5th toes tend toward homogeneity in growth rate. However, some tendency toward irregularity is introduced into this grouping by the somewhat retarded growth of the left 5th toe.

In order to determine whether or not the variation in the mean rate of toe nail growth between individuals is contributing significantly to the heterogeneity of the sample, the F ratio is applied to the figures in Table II. The ratio is the larger mean square, that between means of individuals, to the remainder, or uncontrolled variation, namely, 419.96 to 106.87. Thus:

$$F = \frac{419.96}{106.87} = 3.93$$

When this ratio is compared with the values 1.54 and 1.83 for the 5% and 1% limits of significance (Snedecor, table XXXV) the value of F therefore indicates lack of homogeneity. That is, the mean daily rates of toe nail growth from individual to individual varies significantly and is not wholly attributable to errors in random sampling. Calculating the standard error of the difference between any pair of means

TABLE III

DIFFERENCES BETWEEN VARIOUS TOE MEANS

	R1	R2	R3	R4	R5	L1	L2	L3	L4	L5
R1	......	......	......	......	......	......	......	......	......	......
R2	9.87	......	......	......	......	......	......	......	......	......
R3	7.97	1.90	......	......	......	......	......	......	......	......
R4	5.84	4.03	2.13	......	......	......	......	......	......	......
R5	6.56	3.31	1.41	0.71	......	......	......	......	......	......
L1	1.00	8.87	6.97	4.84	5.56	......	......	......	......	......
L2	8.07	1.80	0.10	2.23	1.51	7.07	......	......	......	......
L3	7.93	1.94	0.04	2.09	1.37	6.93	1.40	......	......	......
L4	6.83	3.04	1.14	0.99	0.27	5.83	1.24	1.10	......	......
L5	11.06	1.19	3.09	5.21	4.50	10.06	2.99	3.13	4.23	......

TABLE IV

TOE MEANS BASED ON AGE CLASSIFICATION

		1	2	3	4	5	Mean	Standard Error
70	R	56.6	46.7	48.6	50.7	50.0		
	L	55.6	48.5	48.6	49.7	45.5		
	M	56.1	47.6	48.6	50.2	48.7	50.1	±.46
Male (33)	R	57.5	45.6	48.3	54.3	55.4		
	L	54.1	48.5	48.8	49.8	46.5		
	M	55.8	47.0	48.5	52.0	50.9	50.9	±.70
Female (37)	R	55.7	47.6	48.9	47.7	47.4		
	L	55.2	49.7	47.2	50.1	44.6		
	M	55.4	48.1	48.0	48.9	46.0	49.4	±.57
Children 1–15 yrs. (20)	R	57.6	49.3	51.8	48.3	52.6		
	L	60.4	48.4	50.5	51.3	49.4		
	M	59.0	48.8	51.0	49.8	51.0	51.9	±.78
Youths 16–25 yrs. (30)	R	56.7	44.1	47.9	53.3	47.1		
	L	53.2	47.7	48.5	49.5	39.0		
	M	54.9	45.9	48.2	51.4	43.0	48.7	±.41
Adults 26+ yrs. (20)	R	55.5	48.2	46.3	49.5	51.3		
	L	54.6	49.8	47.0	48.7	48.6		
	M	55.0	49.0	46.6	49.1	49.9	49.9	±.85

of individuals by the same method as used for that between toes, any mean difference as great as or greater than 9.08 thousandths of 1 mm. can be considered as having contributing causes aside from the variation expected in random sampling.

In Table IV are tabulated the relative mean differences with their standard error of the age and sex subgroups as compared with the total group. The lack of homogeneity of nail growth between individuals is not attributable to age differences for there is almost complete lack of correlation between age and mean growth rate. The observed correlation is —0.12, and a correlation of that size might occur in at least 30% of the samples drawn from an uncorrelated population. Moreover there are no sex differences relative to toe nail growth as far as this sample is concerned, since the mean difference between daily rates of males and females is 1.4 ± .8992 thousandths of 1 mm.

TABLE V

PROBABILITIES OF MEAN DIFFERENCES BETWEEN AGE CLASSES

	Y_1	Y_{2-5}	A_1	A_{2-5}
C_1	.09	....	.14	....
C_{2-5}	....	.01	....	.54
Y_1	....	....	.96	....
Y_{2-5}	....	....	....	.45

However with reclassification into age groups (children 1–15; youths 16–25; adults 26+) and toe groupings, which combine the great toes in one class and the remaining toes in another, certain differences are brought out. When the mean differences are compared in terms of their standard errors and then expressed in terms of their relative probabilities, a summary tabulation, Table V, brings out the following points: the differences between the mean growth rate of the great toe nails do not depart radically from homogeneity in the age classification. The only point of real difference is between the rate of nail growth of the small toes of children and youths, here expressed by the value of .01, meaning that a mean difference as large as that observed (2.91) could occur only once per hundred times if random sampling alone contributed to the variation.

Since the great toes throughout all classifications give a more uniform measure of nail growth than the remaining toes considered as a group, it seems justifiable to use their mean rate as a standard against which to judge abnormal rates of growth. The mean rate of growth of the great toe nails here is 56.1 thousandths of 1 mm. with a standard deviation 12.3. Then, any individual whose daily rate of growth in the great toe nails exceeds 80.7 thousandths of 1 mm. (56.1. + 2 σ) or was less than 31.5 thousandths of 1 mm. (56.1 — 2 σ) could be considered as outside the range of normal growth.

The authors wish to acknowledge valuable assistance rendered by Mrs. Wilma B. Setterfield during the progress of this study.

SUMMARY

1. The mean daily rate of toe nail growth of the 70 apparently normal individuals used in this study was observed to be 50.1 thousandths of 1 mm.
2. The mean daily rate of toe nail growth on corresponding toes does not differ significantly.
3. The mean daily rate of growth of the nails of the great toes, however, is distinctly greater than the rate of the other toes, and for purposes of comparison it is suggested that this difference is worthy of account.
4. Age and mean individual rates showed no significant correlation in the observed sample.
5. There are no sex differences relative to rate of toe nail growth.
6. Age and subclassification into great and remaining toes showed that the most extreme difference in rate of toe nail growth was between the small toes of children (1–15 yrs.) and of youths (16–25 yrs.).

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Scientific Writing

The new third edition of the handbook on the preparation of scientific and technical papers undoubtedly will prove to be as popular and valuable as previous editions. Many valuable suggestions are present within the two covers. Most students and investigators will construct better papers if they follow the suggestions offered.—A. Peterson.

Preparation of Scientific and Technical Papers, by S. T. Trelease and E. S. Yule. 125 pp. Baltimore, The Williams and Wilkins Co., 1936. $1.50.

STUDIES ON FRESH-WATER BRYOZOA

V. Some Additions to Canadian Fauna[1]

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INTRODUCTION

The present paper adds a few species and varieties to the list of fresh-water Bryozoa which have been found previously in Canadian territory. Records by other workers exist for the Georgian Bay region, other parts of Ontario, Quebec and possibly a few other localities. Davenport (1904) gives a few records for the Canadian part of Lake Erie. White (1915) gives a brief resumé of previous finds and also adds considerably to the list. Huntsman (1913) and Geiser (1934) also cite a few localities. White mentions the following species as occurring in Canadian waters:

Paludicella articulata
Fredericella sultana
Plumatella emarginata
Plumatella repens
Plumatella fungosa
Plumatella appressa
Plumatella punctata
Pectinatella magnifica
Cristatella mucedo

Collections for the present study were made from the following Canadian islands in Lake Erie: Middle Sister, East Sister, Pelee, North Harbor, Middle and Hen and Chickens. The following species and forms were found on and around these islands:

Plumatella repens phase *alpha*
Plumatella repens phase *beta*
Plumatella repens var. *appressa*
Plumatella repens var. *emarginata*
Plumatella repens var. *furcifer*
Plumatella repens var. *jugalis*
Fredericella sultana
Paludicella articulata
Cristatella mucedo var. *idae*

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[1] The opportunity for collecting was afforded by the Franz Theodore Stone Biological Laboratory of the Ohio State University, at Put-in-Bay, Ohio.

DISCUSSION OF FORMS

Plumatella repens phase **alpha** Allman 1843

The zooecia are adherent in their entire length. They are reddish-amber in color, translucent to transparent and branch very openly instead of becoming compact. A fuller discussion of this form is found in Study II of this series. It was collected between July 5 and August 28, 1933, from Big Chicken, Middle Sister and Middle Islands, from protected localities along the shore. New to Canada.

Plumatella repens phase **beta** Allman 1848

This form resembles phase *alpha* markedly in coloration, size, zooecial characters and general mode of branching. It differs in that the tubes are not entirely adherent, but that most of the tubes are bent upward at the distal portion of the zooecium. Some of the tubes are upright in a large part of their extent. The tentacles number about 50 to 55. Gradations between phases *alpha* and *beta* are not uncommon. Some colonies are so intermediate that it is impossible to allocate them to either form with absolute certainty.

Collections were made between June 27 and August 28 at the following islands: Pelee, East Sister, Middle Sister and Big Chick. This phase appeared in boulder-protected localities on the under side of stones. New to Canada.

Plumatella repens var. **appressa** (Kraepelin) 1887

1887. *Plumatella polymorpha* var. b, *appressa*. Kraepelin.
1904. *Plumatella polymorpha* var. b, *oppressa*. Davenport.
1915. *Plumatella appressa*. White.
1926. *Plumatella repens* (var. *appressa*)? Despax.
1927. *Plumatella fungosa* var. *appressa*. Abricossoff.

In this form vertical tubes are lacking or very rare. Zooecia are repent, thickly intertwined or pressed closely together on the substratum. The branching is angular. This feature is particularly apparent when a colony is viewed from the attached side. Kraepelin and White mention a clear longitudinal band or low keel as being frequently present. Those features did not appear in the Lake Erie specimens.

The colonies were collected between July 17 and August 28 from North Harbor, Hen and Chickens Islands. They were found on the under side of large stones in localities protected by rocks and boulders. White found it abundant in the Georgian Bay region.

Plumatella repens var. **emarginata** (Allman) 1844

1844. *Plumatella emarginata*. Allman.
1885. *Plumatella repens* (partim). Jullien.
1887. *Plumatella princeps* var. *emarginata* (partim). Kraepelin.
1894. *Plumatella repens* var. *emarginata*. Vangel.
1915. *Plumatella emarginata*. White.

The most conspicuous feature of this variety is the emarginate orifice which connects with the keeled furrow. The tubes are long, cylindrical and keeled. They range in color from a very dark brown to a sandy color, with lighter tips. Tentacles number from 40 to 54. The polypidom is adherent in the greater part of its length. Its branching is open, antler-like and dichotomous.

Statoblasts, in spite of their great variability, have been used as criteria for the identification of species to such an extent that they can not be disregarded. The majority of the free statoblasts of *emarginata* are elongate, less than twice as long as broad but more than 1½ times as long. The annulus covers almost the whole of the upper surface, leaving a small exposed central capsule area.

The distribution of this form is very wide, in North America, Europe, Asia and Africa. Davenport (1904), Osler ? (1883), Huntsman (1913) and White (1915) reported it from various localities in Canada. In the 1932–33 collections it was found on or around East Sister, Middle Sister, Middle, Pelee, Hen and Chickens Islands. The best specimens came from protected localities or pond habitats.

Plumatella repens var. **furcifer** Jullien 1885

Only a few colonies of this form were found—at Pelee Island, on August 22. The habitat was a protected shore locality where coarse rubble, mud and sand were present. This form is more luxuriant ordinarily in pond habitats.

Variety *furcifer* is easily recognized wherever encountered by the transparent, bifurcated, longitudinal area which is present on most of the zooecia, although it sometimes is not very conspicuous. The ectocyst varies from a reddish-brown color to transparency, and, is not very rigid. The orifice is emarginate. Tentacles number about 50. The tubes are entirely adherent. The branching is open. New to North America.

Plumatella repens var. **jugalis** (Allman) 1850

The zooecia are entirely adherent and provided with a keel. The colony is geminate and the branching is very open. Tentacles number about 40. No other variety except *flabellum* possesses the geminate character whereby two portions of the colony are connected basally, by a tube. *Flabellum* can be easily distinguished from *jugalis* in its extremely luxuriant branching and flabellate character. The variety *jugalis* was found in only one Canadian locality—in an old canal on Pelee Island on June 21. New to North America.

Fredericella sultana (Blumenbach) 1777

1777. *Tubularia sultana.* Blumenbach.
1836. *Plumatella sultana.* Dumortier.
1887. *Fredericella sultana.* Kraepelin.

This species resembles the Plumatellas very closely. It branches antler-like, with long cylindrical tubes either recumbent, erect or a combination of both. The branching is very open, even in "bushy" colonies. No free statoblasts are found. The attached stoblasts show various markings. In young statoblasts the unattached surface is more or less smooth while in old statoblasts the surface is roughened. The shape of these reproductive bodies is variable—some of them may be reniform, some oval, others almost quadrangular and still others almost circular. The average length of the Erie specimens was 0.366 mm. and the average breadth was 0.199 mm.

Abricossoff recognized several varieties of *F. sultana*. However, these varieties should be more carefully and fully described and illustrated.

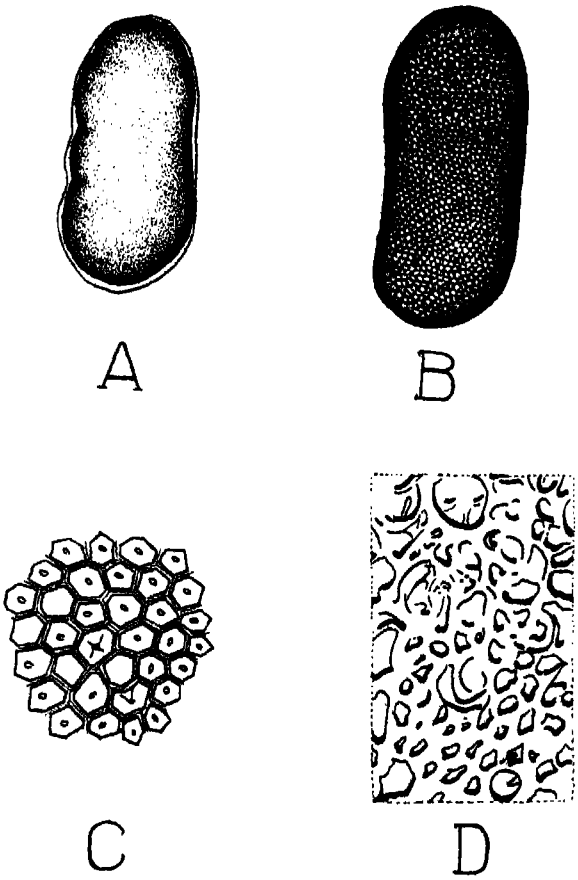

FIG. 1. *A.*—A young statoblast of *Fredericella sultana*. The unattached surface is quite smooth. Dimensions 0.4176 mm. long, 0.1914 mm. wide. *B.*—An older statoblast of *F. sultana*. *C.*—An enlarged drawing of the surface of *B*. *D.*—A portion of the roughened surface of an old statoblast of *F. sultana*. The magnification is the same as in *C*. All figures were made with the aid of a camera lucida.

Fredericella sultana has been recorded from a number of localities in North America, Europe, Asia, Australia and South America. White found it in the Georgian Bay region while Huntsman recorded it from Bond Lake in the Toronto district. In Lake Erie it was present in collections from Pelee, North Harbor, Middle, Middle Sister, East Sister, Hen and Chickens.

Paludicella articulata (Ehrenberg) 1831

1831. *Alcyonella articulata.* Ehrenberg.
1836. *Paludicella articulata.* Gervais.
1856. *Paludicella Ehrenbergi.* Allman.
1887. *Paludicella Ehrenbergii.* Kraepelin.

This species is very readily recognized when seen in the collections. Its zooceia are club-shaped, elongate and very slender. They are almost 2 mm. long. The circular lophophore bears 16 to 18 tentacles. The lateral buds may be repent or erect. The tubular orifice is squared at the tip and is placed distally with respect to the enlarged portion of the body. The Erie individuals varied considerably both in length and width of zooecia. This species is very common in the southwestern part of the Lake. It is rather surprising that neither Davenport nor Landacre listed its occurrence in the Lake—unless of course it may have been introduced there later. It occurred at Hen, Middle, Southeast Chicken, Northwest Chicken, Big Chicken, East Sister, Middle Sister, North Harbor and Pelee Islands. Collections of this form were made between June 21 and August 30.

Cristatella mucedo var. **idae** (Leidy) 1858

1858. *Cristatella Idae.* Leidy.
1887. *Cristatella mucedo* var. *Idae.* Kraepelin.
1908. *Cristatella mucedo.* Loppens.

The Lake Erie variety agreed in a number of features with Kraepelin's *Idae.* The colonies were ribbon-like and had three marginal rows of polypides. Tentacula numbered between 70 and 74. Very few statoblasts were found, but, those which were available, had approximately 24 hooks on one side and 45 on the other. The diameter of one statoblast was 1.075 mm.

The question as to the validity of the varieties *idae* and *genuina* was referred to in Study II and will not be discussed here. Variety *idae* has not been recorded from Lake Erie by either Davenport or Landacre. The writer has found it in only three Canadian localities: Big Chick, East Sister and Middle Sister Islands. Davenport records Reighard's findings of the variety *genuina* at Long Point, Canada. New to Canada.

SUMMARY

1. At least nine species and varieties of fresh-water Bryozoa have been recorded from Canada by earlier workers.
2. The present study discusses nine species, varieties and phases, which were collected on and around several islands in the southwestern part of Lake Erie (Canadian territory), during the summers of 1932 and 1933.
3. Of these nine forms of the present study two were new for North America:
   (a) *Plumatella repens* var. *jugalis*
   (b) *Plumatella repens* var. *furcifer*

4. Three forms, subdivisions of previously recorded species, have also been added to the list:
   - (a) *Plumatella repens* phase *alpha*
   - (b) *Plumatella repens* phase *beta*
   - (c) *Cristatella mucedo* var. *idae*

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Plant Hormones

The first comprehensive account of plant growth substances will be welcomed by botanists and biologists generally. It is a volume which plugs an obvious gap on every botanical bookshelf. The book is basically a translation and revision of Boysen-Jensen's "Die Wuchsstofftheorie." The author's original version has been considerably rearranged and brought up to date with the inclusion of the literature through 1935. The reorganization and revision have been skillfully done. The result is a straightforward, lucid account of present knowledge of the roles of growth substances in plants. The text is adequately supported with illustrations. About 500 papers are listed in the bibliography. A supplementary bibliography lists about 150 titles on the subject of the effects of "bios" and other similar substances on plant growth. These are not, however, discussed in the text.—B. S. MEYER.

Growth Hormones in Plants, by G. S. Avery and P. R. Burkholder. 268 pp. New York, the McGraw-Hill Book Co., 1936. $3.50.

SOME NEW SPECIES OF BALLANA (HOMOPTERA CICADELLIDAE)

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During the past six years the writer has been studying the species of this genus, determining and illustrating both male and female genital characters. It was planned to publish the illustrations with the descriptions of all the species in the genus. Certain conditions, however, have indicated the advisability of publishing the following descriptions in order to use the names for the identification of species. As a consequence the portions of the descriptions concerned with the dorsal pieces of the male genitalia, which offer excellent characters for separation, are omitted as are the several plates of illustrations. These will appear at a later date after the names are established. The material upon which this study has been based is contained in the collections of Dr. E. D. Ball and the author. Dr. Ball has furnished type material of previously described species and unidentified material, a considerable amount of which has proved to be undescribed. The author is greatly indebted for this assistance and desires to express his grateful appreciation to Dr. Ball.

Ballana atridorsum (Van Duzee)

Thamnotettix atridorsum V. D. Can. Ent. 36:92, 1894.

The original female type of this species was destroyed and Professor Herbert Osborn erected a topotype ♂ from the same series. This is in the Iowa State College Collection labeled Colo. 581. It is here designated as the neotype and the genitalia are thus described:

Male plates slightly longer than combined basal width, sides almost straight, apices rather broad, rounded, extending to the posterior spines. Male in dorsal view with ninth segment broader than long, narrowed from base to apex. Anterior spines very short, arising at posterior portion and directed caudally. Posterior spines long and heavy, extending beyond median line and slightly curving upward.

Ballana delea n. sp.

Resembling *atridorsum* but with distinct genitalia. Length 5 mm.

Vertex produced, bluntly angled, and bluntly angled with front, about one third wider between eyes than length at middle.

Genitalia: Female last ventral segment with lateral angles rounded, posterior margin between these slightly indented, forming a broad median truncated portion. Male plates broad, only slightly longer than combined basal width, strongly convexly rounded to bluntly pointed apices which do not reach to the posterior spines.

Described from a pair of specimens from Santa Barbara, California, collected in June, 1918. Holotype male and allotype female in author's collection.

Ballana calcea n. sp.

Resembling *atridorsum* in general appearance but smaller and with distinct genitalia. Length 5 mm.

Vertex bluntly angled, length at middle more than half basal width between eyes, margin of vertex thick.

Color: Pale green, vertex yellowish green.

Genitalia: Female last ventral segment with lateral margins convexly rounding to form broadly rounded lobes between which the central third of the posterior margin is slightly excavated. The posterior margin of the excavation slightly convexly rounded. Male plates long, slightly longer than combined basal width, sides almost straight, apices blunt, rounded, reaching almost to posterior spines.

Described from a series of six male and two female specimens collected at Bunkersville, Nevada, April 17, 1929, (Davis); two males and two females, Glendale, Nevada, May 5, 1929, (Fox) from *Hymenoclea salsola;* and one female as Mesquite, Nevada, June 7, 1929, from *Franseria eriocentra*. Holotype male, allotype female (Bunkerville, Nevada) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana brevidens n. sp.

Resembling *atridorsum* in general form and appearance but with distinct genitalia. Length 5.5 mm.

Vertex slightly produced, bluntly angled, bluntly angled with front, twice as wide between eyes as length at middle.

Color: Yellowish, elytra very pale, dull green, apices of elytra slightly smoky.

Genitalia: Female last ventral segment with lateral angles broadly rounded to median third of posterior margin which is indented, almost truncate and black margined. Male plates about as long as combined width at base, sides almost straight, apices bluntly pointed, just reaching the posterior spines.

Described from one male and six female specimens collected at Minidoka, Idaho, June 24, 1930. Holotype male, allotype female and female paratypes in the author's collection. Female paratype in Ball Collection.

Ballana transea n. sp.

Resembling *atridorsum* in general appearance but with vertex more produced and with distinct genitalia. Length 5 mm.

Vertex produced and bluntly angled, margin thick, bluntly angled with front about one third wider between eyes than length at middle.

Color: Vertex pronotum and scutellum yellowish, elytra dull green.

Genitalia: Female last ventral segment short, posterior margin practically truncate, scarcely indented, central two thirds broadly dark margined. Male plates about as long as combined basal width, sides almost straight, apices bluntly pointed, reaching to posterior spines.

Described from three specimens from Colorado without specific data. Holotype male, allotype female and female paratype in author's collection.

Ballana adversa n. sp.

Resembling *atridorsum* in general form and appearance but smaller and with distinct genitalia. Length 4.5 mm.

Vertex produced and bluntly angled, two thirds as long at middle as basal width between eyes, margin thick and bluntly angled with front.

Color: Yellowish, pronotum and elytra tinged with green, apices of elytra slightly smoky.

Male plates a little longer than combined basal width, sides straight, apices blunt, rounded, reaching the posterior spines.

Described from two male specimens collected at Stansburg I. Park, Utah, June 13, 1913, by Hagan Titus; two males from Santa Clara, Utah, May 5, 1929, (Fox). Holotype male and male paratypes in author's collection. Paratype male in Ball collection.

Ballana firma n. sp.

In form and general appearance resembling *atridorsum* but with distinct genitalia. Length 5 mm.

Vertex produced but bluntly angled and bluntly angled with front. One fifth wider between eyes than length at middle.

Color: Vertex, anterior margin of pronotum and scutellum yellow, disc of vertex and elytra dark green, veins paler. Apices of elytra black to anterior cross veins of inner and outer apical cells.

Genitalia: Female last ventral segment convexly rounded from near base to posterior margin which is deeply concavely rounded between these two pointed lobe-like portions. Male plates a little longer than combined basal width, side margins convexly rounded to blunt rounded apices which reach beyond the posterior spines.

Described from a series of two male and one female specimens collected at Alpine, California, July 5, 1931, by Dr. E. D. Ball. Holotype male and allotype female in Ball collection. Paratype male in author's collection.

Ballana prava n. sp.

In form and general appearance resembling *firma* but more slender, with vertex more produced and with distinct genitalia. Length 5 mm.

Vertex produced and bluntly angled, almost one-half wider between eyes than length at middle.

Color: Vertex yellow, pronotum, scutellum and elytra green. Apices of elytra black as far forward as cross veins of apical cells.

Genitalia: Male plates not quite as long as combined basal width, triangular, sides almost straight, slightly concave, apices bluntly pointed, not reaching posterior spines by about one-third their length.

Described from two male specimens collected at San Luis Obispo, California, collected June 14, 1934, by Dr. E. D. Ball. Holotype male and paratype male in Ball collection.

Ballana elexa n. sp.

Resembling *firma* in general appearance and coloration but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, margin of vertex thick, one-third wider between eyes than length at middle.

Color: Vertex, anterior margin of pronotum and scutellum yellowish, disc of pronotum and elytra yellowish green, veins paler, apices of elytra dusky to brown.

Genitalia: Female last ventral segment convexly rounded from near base to form posterior margin which is almost truncate, slightly indented either side of median third. Male plates about as long as combined basal width side margins almost straight, apices broad, bluntly pointed on inner margin, not reaching to posterior spines.

Described from a series of two male and two female specimens collected at Pine Valley, California, July 6, 1931, by Dr. E. D. Ball. Holotype male and allotype female in Ball collection. Male and female paratypes in author's collection.

Ballana attenuata n. sp.

Resembling *vivata* in general appearance but with distinct genitalia. Length 5 mm.

Vertex strongly produced and bluntly angled, bluntly angled with front, one-fourth wider between eyes than length at middle.

Color: Vertex and scutellum yellow, pronotum and elytra green washed with yellow, veins indistinct except at apex where they are pale on a slightly smoky, subhyaline apical portion.

Genitalia: Male plates as long as combined basal width, more than half as broad at apex as width at base, apices broadly rounded, reaching posterior spines.

Described from a single male specimen collected at Pine Valley, California, July 6, 1931, by Dr. E. D. Ball. Holotype male in Ball collection.

Ballana filamenta n. sp.

Resembling *attenuata* in form and general appearance but with blunter head and distinct genitalia. Length 6–6.5 mm.

Vertex well produced and rather sharply angled, acutely angled with front, one-half wider between eyes at base than median length.

Color: Vertex and anterior portion of pronotum yellow, disc of pronotum, scutellum and elytra green. Veins of elytra pale, apices subhyaline.

Genitalia: Female last ventral segment with lateral margins slightly narrowed and produced, posterior margin forming two broadly rounding lobes between which is a broad U-shaped notch extending two thirds the distance to base and broadly black margined at apex. Male plates a little longer than combined basal width, at least one-third as wide at apex as base, apices broadly rounded, not reaching posterior spines.

Described from a male and female specimens from Yosemite, California, collected June 28, 1931, and a female from Santa Margarita, California, collected June 23, 1931, all by Dr. E. D. Ball. Holotype male, allotype female (both from Yosemite) in Ball collection. Female paratype in author's collection.

Ballana mera n. sp.

Resembling *filamenta* in general form and appearance but with vertex more bluntly angled and with distinct genitalia. Length 5.5 mm.

Vertex produced and bluntly angled, one and one-third times as wide between eyes at base as length at middle.

Color: Vertex, yellow; pronotum, scutellum and elytra green washed with yellow, veins paler.

Genitalia: Female last ventral segment with lateral margins convexly rounded from about half its length to posterior margin which is truncate at middle. Male plates not quite as long as combined basal width, convexly rounded to broadly rounded apices which do not reach posterior spines by more than one-third their length.

Described from a series of two male and one female specimens collected at Muir Woods, California, June 17, 1934, by Dr. E. D. Ball. Holotype male, allotype female in Ball collection. Paratype male in author's collection.

Ballana quira n. sp.

In form and general appearance resembling *atridorsum* but with distinct genitalia. Length 5–5.5 mm.

Margin of vertex thick, vertex bluntly angled, more than one-half wider between eyes than length at middle.

Color: Vertex, anterior margin of pronotum and scutellum yellowish. Disc of pronotum and elytra dull yellowish green.

Genitalia: Female last ventral segment strongly convexly rounding from about half its length to almost truncate posterior margin, the central third of which is slightly indented but truncate. Male plates about as long as combined basal width, sides almost straight, apices rather broad, rounded to bluntly pointed tips, not reaching to posterior spines.

Described from two male and two female specimens collected at Sunset Park, Arizona, June 23, 1935, by Dr. E. D. Ball. Male holotype, female allotype and male and female paratypes in Ball collection. Male and female paratypes in author's collection.

Ballana nigridens n. sp.

Resembling *atridorsum* in general appearance but with vertex blunter and with distinct genitalia. Length 6.5 mm.

Vertex bluntly angled, margin thick, bluntly angled with front, more than twice as wide between eyes as length at middle.

Color: Vertex yellow, pronotum dull green, anterior margin yellowish. Elytra dull greenish, apices slightly smoky, arcs on face pale brown, slightly visible from above.

Genitalia: Female last ventral segment strongly produced and narrowed, posterior margin broadly slightly indented forming a slightly rounded median lobe. Male plates rather long, almost one-fourth longer than combined width at base, slightly concavely narrowed on outer margin about middle, apices bluntly pointed, not reaching end of anal tube.

Described from a pair of specimens collected at Jemez Springs, N. M., June 15, 1919. Holotype male and allotype female in the author's collection.

Ballana spinosa n. sp.

Resembling *atridorsum* in general appearance but with more bluntly angled vertex and distinct genitalia. Length 6 mm.

Vertex very blunt, almost rounded in front, margin thick, rounding to front, almost twice as wide as length at middle.

Color: Vertex pale yellow, pronotum, scutellum and elytra dull greenish.

Genitalia: Female last ventral segment with posterior margin indented on median half forming a slightly sunken truncate lobe. Male plates short and broad, only slightly longer than combined basal width, convexly rounded to form obliquely rounding apices which do not reach the junction of the posterior spines.

Described from a series of four male and three female specimens collected at Idaho City, Idaho, July 13, 1930, by the author. Holotype male, allotype female and male and female paratypes in the author's collection.

Ballana polica n. sp.

Resembling *spinosa* in general form and appearance but with distinct genitalia. Length 5.5 mm.

Vertex blunt, scarcely produced at middle, twice as wide between eyes at base as length at middle, margin thick, almost rounded to front.

Female last ventral segment with lateral angles rounded, median third of posterior margin indented, concavely rounded. Male plates about as long as combined basal width, sides convexly rounded, apices rather broad and blunt, reaching the posterior spines.

Described from a male specimen from Aberdeen, Idaho, June 26, 1930, (DeLong); and eight females and fourteen males from Craters of the Moon, Idaho, June 29, 1930. Holotype male, allotype female and male and female paratypes in the author's collection. Male and female paratypes in Ball collection.

Ballana parallela n. sp.

Resembling *spinosa* in general appearance but with distinct male genitalia. Length 5 mm.

Vertex scarcely produced, rounded, almost half as long at middle as basal width between eyes, margin thick, bluntly angled with front.

Color: Yellowish, elytra slightly tinged with dull green.

Male plates a little longer than combined width at base, sides convexly rounded, apices blunt, rounded, not reaching the posterior spines. Male in dorsal view with ninth segment broader than long. Anterior spines and posterior spines long, straight and heavy, both pairs extending obliquely caudally so that they appear parallel.

Described from one male specimen collected at Twin Falls, Idaho, Aug. 30, 1927, which seems unique and to deserve specific treatment. Holotype male in author's collection.

Ballana curvidens n. sp.

Resembling *spinosa* in form and appearance but with distinct genitalia. Length 5.5 mm.

Vertex roundedly produced but scarcely angled, margin thick, rounding to front, almost twice as wide between eyes as length at middle.

Color: Vertex yellowish, pronotum, scutellum and elytra dull greenish.

Genitalia: Last ventral segment with posterior margin forming a slightly indented median lobe on central half. Male plates rather long, about one-fourth longer than combined basal width, slightly convexly rounded to bluntly pointed apices which do not reach the end of the anal tube.

Described from a series of 38 specimens. Four male specimens from Minidoka, Idaho, June 24, 1930; 7 males and 14 females from American Falls, Idaho, June 25, 1930; 8 males and 5 females, Twin Falls, Idaho, June 14, 1930; and one male, Craters of the Moon, Idaho, June 29, 1930, all collected by the author. Holotype male (Minidoka, Idaho) allotype female (American Falls) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana ortha n. sp.

Resembling *spinosa* in form and general appearance but with distinct genitalia. Length 5.5 mm.

Vertex produced and rounded at apex, margin very thick, rounded to front, about twice as wide between eyes as length at middle.

Color: Vertex and scutellum yellowish, pronotum and elytra dull green.

Genitalia: Last ventral segment of female with central half of posterior margin roundedly produced forming a broad, truncated lobe which is heavily black margined and more caudal than remainder of segment. Male plates not quite as long as combined basal width, triangular, gradually narrowed to bluntly pointed apices which do not reach to the branches of the posterior spines.

Described from a male specimen collected at Logan Canyon, Utah, July 24, 1930, (DeLong); four females and one male, Minidoka, Idaho, June 24, 1930, (DeLong); four males, Overton, Nevada, July 7, 1929, (Fox); one female, Cove Fort, Utah, July 6, 1928, (Davis); two females, Bliss, Idaho, June 6 and 16, 1930; and four males and four females from Dixie, Utah, June 27, 1931, (Ball). Holotype male allotype female (Minidoka, Idaho) and male and female paratypes in author's collection, male and female paratypes in Ball collection.

Ballana calcara n. sp.

Resembling *spinosa* in general form but with distinct genitalia. Length 5.5 mm.

Vertex bluntly angled, almost half as long at middle as basal width between eyes.

Color: Vertex and pronotum yellow, scutellum pale green, elytra rather bright green, margin thick.

Genitalia: Female last ventral segment with lateral margins produced almost straight from base to broadly curved outer lobes of posterior margin between which the central third is rather deeply, broadly excavated, the apical truncated margin of which is broadly embrowned. Male plates as long as combined basal width, convexly rounded to blunt apices, reaching only about two thirds the distance to the posterior spines.

Described from five male and five female specimens collected at Dunphy, Nevada, Aug. 5, 1930, from *Chrysothamnus* sp. Holotype male, allotype female and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana hebea n. sp.

Resembling *calcara* in form and size but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, more than half as long on middle as basal width between eyes, margin thick.

Color: Pale, dirty yellow, elytra slightly tinged with green. Veins pale, conspicuous.

Genitalia: Female last ventral segment with lateral margins convexly rounding to form rounded lobes of posterior margin between which the median third is distinctly abruptly excavated, the apex of which is truncated. Male plates a little longer than combined basal width, appearing long, sides almost straight, apices blunt, slightly longer than distance to posterior spines.

Described from a series of two male specimens collected at Benjamin, Utah, July 23, 1930, (DeLong); one male from Brigham, Utah, July 5, 1929, (Knowlton); five males and two females, Ely, Nevada, July 9, 1930 (Davis and Dorst); four females, N. Payson, Utah, July 25, 1930, (DeLong); two males, Richfield, Utah, July 15, 1929, (Dorst); June 21, 1930, (Davis); one male, Elko, Nevada, July 12, 1930, (Dorst).

Holotype male (Benjamin, Utah) allotype female (N. Payson) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana occidentalis n. sp.

Resembling *calcara* in form and general appearance but with vertex more blunt and with distinct genitalia. Length 5.5 mm.

Vertex bluntly angled, not more than one-half broader between eyes than length at middle.

Color: Vertex yellow, pronotum, scutellum and elytra pale, dull green, apices of elytra smoky.

Male plates together slightly broader than long, lateral margins convexly rounded, apices blunt, rounded, extending only about two-thirds the distance to posterior spines.

Described from two male specimens from Elko, Nevada, collected July 12, 1930, from *Chrysothamnus*. Holotype male and paratype male in author's collection.

Ballana absenta n. sp.

Resembling *calcara* in general form but paler in color and with distinct genitalia. Length 5.5 mm.

Vertex bluntly angled, almost twice as wide between eyes as length at middle, anterior margin thick.

Color: Pale straw yellow, elytra slightly tinted with green.

Genitalia: Female last ventral segment with lateral margins convexly rounding to form produced, angular lobes either side of a broad excavated central half with truncated margin and excavated about one-fourth the distance to the base. Male plates small, about as long as combined width at base, sides almost straight, apex blunt, rounded, not reaching posterior spines by about one-third their length.

Described from six female and one male specimens collected at Overton, Nevada, June 6 and July 7, 1929, (Fox); one female and one male, St. George, Utah, June 4, 1930, (Davis); three females, Glendale, Nevada, May 5, 1929, (Fox); one female, Richfield, Utah, August 7, 1916. Holotype male (Overton, Nevada) allotype female (same) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana coarcta n. sp.

Resembling *callida* in general appearance but with blunter vertex and distinct genitalia. Length 5 mm.

Vertex strongly produced, apex bluntly angled, one-fourth wider between eyes at base than median length.

Color: Vertex and scutellum yellowish, elytra and disc of pronotum dull greenish, apex of elytra black.

Genitalia: Female last ventral segment decidedly narrowed to posterior margin which is broadly, shallowly emarginate more than half its width. Male plates long and slender, longer than combined basal width, sides concave, apices bluntly pointed, almost reaching to posterior spines.

Described from a male and two female specimens collected at Alpine, California, July 5, 1931, by E. D. Ball. Holotype male and allotype female in Ball collection, female paratype in author's collection.

Ballana sera n. sp.

Resembling *atridorsum* in form and general appearance but larger, with vertex more bluntly angled and with distinct genitalia. Length 6–6.5 mm.

Anterior margin thick, vertex bluntly angled, one and one-half times as wide between eyes as length at middle.

Color: Vertex, anterior margin of pronotum and scutellum yellowish. Disc of pronotum and elytra yellowish, appearing green where covering abdomen.

Genitalia: Female last ventral segment with lateral margins convexly rounding from near base to posterior margin, the central third of which is abruptly excavated about one-fourth the distance to base, the base of which is slightly convexly rounded. Male plates about as long as combined basal width, sides convexly rounded, apices bluntly pointed, not reaching to posterior spines by about one-fourth their length.

Described from a series of two female and three male specimens collected at Beaumont, California, June 12, 1931, by Dr. E. D. Ball. Male holotype, female allotype in Ball collection. Male paratype in author's collection.

Ballana plena n. sp.

Resembling *sera* in general appearance but with broader head and distinct genitalia. Length 5.5–6 mm.

Vertex very broadly, bluntly angled, margin thick, slightly more than one and one-half times as wide as median length.

Color: Vertex, anterior margin of pronotum and scutellum yellow, brownish arcs of front extending up onto anterior margin of vertex. Disc of pronotum and elytra green washed with yellow, veins of wing paler.

Genitalia: Female last ventral segment with lateral margins convexly rounding from near base to posterior margin which is broadly V-shaped, notched at center, about one-third the distance to base. Apex of notch broadly black. Male plates as long as combined basal width, sides slightly convexly rounded, apices broad, obliquely sloping to blunt apices, not reaching posterior spines.

Described from one male and one female specimens collected at Pine Valley, California, July 6, 1931, by Dr. E. D. Ball. Male holotype and female allotype in Ball collection.

Ballana gruis n. sp.

Resembling *vesca* in general form and appearance but with distinct genitalia. Length 4–5 mm.

Vertex bluntly angled, almost rounded in front, margin thick, one-fourth wider between eyes than length at middle.

Color: Vertex pronotum and scutellum yellowish, disc of pronotum green. Elytra green, veins yellowish.

Genitalia: Female last ventral segment convexly roundedly narrowed to posterior margin which occupies the middle half of segment and is truncated or slightly convexly rounded. Lateral plates prominent. Male plates about as long as combined basal width, sides almost straight, apices bluntly pointed, almost rounded, not quite reaching to posterior spines.

Described from a male and two female specimens collected at Oxnard, California, June 21, 1931, by Dr. E. D. Ball. Holotype male allotype female in Ball collection. Paratype female in author's collection.

Ballana indens n. sp.

In general appearance resembling *vetula* but with distinct genitalia. Length 5–5.5 mm.

Vertex bluntly angled, almost rounded, one-third wider between eyes at base than median length. Margin thick.

Color: Pale yellow, pronotum and elytra slightly darker.

Genitalia: Female last ventral segment narrowed to apex, lateral angles bluntly rounded between which the posterior margin is slightly emarginate and truncate. A heavy black mark causes it to appear rather deeply and doubly notched. Male plates about as long as combined basal width, broadly triangular, apices broadly blunt and rounded, not reaching posterior spines by about one-third their length.

Described from two male and two female specimens collected at Doyle, California, July 21, 1912. Holotype male, and allotype female in Ball collection. Male and female paratypes in author's collection.

Ballana diutia n. sp.

In form and appearance resembling *vesca* but with distinct genitalia. Length 4.5 mm.

Vertex bluntly angled almost twice as wide between eyes as length at middle. Margin thick, almost rounded to front.

Color: Vertex and scutellum yellow, pronotum and elytra gray tinged with yellow.

Male plates about as long as combined basal width, sides convexly rounded, apices broad, rounded, reaching almost to posterior spines.

Described from a single male specimen collected at Mojave, California, July 1, 1931, by E. D. Ball. Holotype male in Ball collection.

Ballana pleura n. sp.

Resembling *atridorsum* in general form and appearance but with distinct genitalia. Length 5–5.5 mm.

Vertex produced and bluntly angled, one and one-half times as wide between eyes at base as median length.

Color: Male, vertex and scutellum yellow, pronotum and elytra green, veins paler, apices of elytra smoky. Female yellowish washed with brown, veins pale.

Genitalia: Female last ventral segment with lateral margins strongly, convexly rounded from base to posterior margin which is truncated on central third and slightly indented. Male plates about as long as combined basal width, concavely rounded on outer margins to form bluntly pointed apices, which do not reach to the posterior spines.

Described from a series of three male and one female specimens collected at Santa Margarita, California, June 23, 1931, by Dr. E. D. Ball. Holotype male, allotype female and male paratype in Ball collection. Paratype male in author's collection.

Ballana hama n. sp.

Resembling *pleura* in general appearance but with more produced vertex and distinct genitalia. Length 4.5 mm.

Vertex strongly produced and bluntly angled, one and one-half times as wide between eyes as length at middle.

Color: Greenish washed with yellow, pale brownish arcs extending onto margin of vertex from front. A pair of small brown spots on base of vertex. Elytra with apices smoky, veins pale.

Genitalia: Female last ventral segment with lateral margins obliquely sloping to posterior margin which is slightly excavated on median third and truncated. Male plates as long as combined width at base, sides almost straight, apices bluntly pointed, almost reaching posterior spines.

Described from a series of two male and one female specimens collected at Beaumont, California, June 12, 1921, by Dr. E. D. Ball. Holotype male and allotype female in Ball collection. Paratype male in author's collection.

Ballana valga n. sp.

Resembling *pleura* in form but with pale yellow color and distinct genitalia. Length 5 mm.

Vertex bluntly angled only slightly produced, one and two-thirds times as wide between eyes as median length, margin thick.

Color: Pale yellowish without definite markings, veins pale.

Genitalia: Female last ventral segment with lateral margins strongly convexly rounding from base to posterior margin which is shallowly, evenly and rather broadly concave. Male plates as long as combined basal width, side margins slightly concavely rounded to form bluntly pointed apices which do not reach the posterior spines by about one-fourth their length.

Described from a series of one male and two female specimens collected at Provo, Utah, August 9, 1930. Holotype male and allotype female in Ball collection. Paratype female in author's collection.

Ballana angula n. sp.

In general form resembling *valga* but with greenish color and distinct genitalia. Length 5 mm.

Vertex only slightly produced and bluntly angled, twice as wide between eyes at base as median length.

Color: Male pale green tinged with yellow, female pale yellow, unmarked.

Genitalia: Female last ventral segment with lateral margins strongly convexly rounded from base to posterior margin which is slightly and broadly excavated, the posterior margin of which is convexly rounded. Male plates about as long as combined basal width, side margins straight, apices rather broad, rounded, not reaching posterior spines by about one-third their length.

Described from four male and two female specimens collected at Gila Bend, Arizona, April 13, 1933, by Dr. E. D. Ball. Holotype male, allotype female and paratype males in Ball collection. Paratype male and female in author's collection.

Ballana tiaja n. sp.

Resembling *vetula* in general appearance and coloration but larger and with distinct genitalia. Length 5.5–6 mm.

Vertex broadly rounded, one and one-half times as wide between eyes at base as median length, margin thick bluntly angled with front.

Color: White to pale yellow, disc of pronotum and elytra appearing gray.

Genitalia: Female last ventral segment narrowed to bluntly rounded lateral angles between which the posterior margin is slightly excavated and the margin is slightly convexly rounded. Male plates about as long as combined basal width, broadly triangular, sides slightly concave at middle, apices broad, blunt, rounded, not reaching to posterior spines.

Described from a series of two female and three male specimens collected at Tia Juana, Mexico, August 2, 1912, and one male, same locality, June 15, 1908, by Dr. E. D. Ball. Holotype male, allotype female and male paratypes in Ball collection. Male and female paratypes in author's collection.

Ballana recurvata n. sp.

Resembling *vastula* in form and appearance but with distinct genitalia. Length 5–5.5 mm.

Vertex sharply angled, apex blunt, bluntly angled with front, about one-fourth wider between eyes than length at middle.

Color: Vertex and scutellum yellowish, pronotum dull green, elytra dull greenish, apical portion posterior to cross veins brownish.

Genitalia: Female last ventral segment roundedly produced, central third forming a slightly sunken almost truncated lobe. Male plates rather long, about one-fourth longer than combined width at base, gradually sloping to bluntly pointed apices which extend just to apex of anal tube.

Described from four female and two male specimens collected from carrots, turnips, and beans at Boise, Idaho, July 11, 1930, (DeLong); five males and three females collected at Santa Margarita, California, June 23, 1931, (Ball); and four females and two males from Medford, Oregon, June 26, 1934, (Ball). Holotype male, allotype female (Boise, Idaho) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana bifida n. sp.

Resembling *titusi* but with vertex more bluntly angled and with distinct genital characters. Length 4.5 mm.

Vertex bluntly angled, about one-fourth wider between eyes at base than length at middle.

Color: Vertex, pronotum and scutellum yellowish, disc of pronotum dark green. Elytra dark green, venation pale, apices subhyaline.

Genitalia: Female last ventral segment with lateral margins rounded to form outer rounded lobes of posterior margin between which the central third is broadly shallowly emarginate. Male plates long and narrow, a little longer than combined width at base, sides slightly concave, apices bluntly pointed reaching the posterior spines.

Described from a series of four male and seven female specimens collected at Craters of the Moon, Idaho, June 29, 1930, Idaho City, Idaho, July 13, 1930, and Murtaugh, Idaho, June 21, 1930, by the author; Holotype male and allotype female (both from Craters of the Moon) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana dira n. sp.

Resembling *attenuata* in general form but pale in color and with distinct genitalia. Length 5.5–6 mm.

Vertex rather sharply angled, one-third wider between eyes at base than median length, rather sharply angled with front.

Color: Vertex and scutellum yellowish, pronotum and elytra rather pale dull green.

Genitalia: Female last ventral segment sloping from base to narrowed posterior margin which is rather squarely, broadly and shallowly excavated on median half, base of excavation black margined. Male plates as long as combined width at base, sides convexly rounded, apices broad, bluntly rounded, almost reaching to posterior spines.

Described from a series of two male and one female specimens collected at Tucson, Arizona, April 10, 1931; two male and two female specimens at Tinajas Altas, Ariz., March 27, 1932, and three male and one female specimens at Ajo Mts., Ariz., April 21, 1930, all by Dr. E. D. Ball. Holotype male, allotype female (Tucson, Ariz.), and male and female paratypes in Ball collection. Male and female paratypes in collection of the author.

Ballana cuna n. sp.

Resembling *ortha* in form and general appearance but with head even more blunt and with distinct genitalia. Length 5–5.5 mm.

Vertex very blunt, almost rounded in front, almost twice as wide between eyes as length at middle, margin of vertex thick.

Color: Vertex yellow, pronotum, scutellum and elytra green, tinged with yellow, veins of elytra paler.

Genitalia: Female last ventral segment with lateral margins sloping and posterior margin narrowed, sinuate, a narrow shallow U-shaped notch at center. Male plates as long as combined width at base, sides slightly convexly rounded, apices bluntly pointed, not reaching to posterior spines.

Described from a series of four male and four female specimens collected at Weed, California, June 22, 1934, by Dr. E. D. Ball. Holotype male, allotype female and male and female paratypes in Ball collection. Male and female paratypes in author's collection.

Ballana seca n. sp.

Resembling *cuna* in form and general appearance but with distinct genitalia. Length 5.5–6 mm.

Vertex broadly rounded, almost twice as wide between eyes as median length. Margin thick, rounded to front.

Vertex and scutellum yellowish, pronotum and elytra dull green, veins pale.

Genitalia: Female last ventral segment narrowed to posterior margin which is broadly rather squarely excavated on median half. Male plates not quite as long as combined basal width, sides slightly concave, apices rather broad, bluntly pointed, not reaching posterior spines by about one-third their length.

Described from a series of four male and four female specimens collected at Lebec, California, June 28, 1934, by E. D. Ball. Holotype male, allotype female and male and female paratypes in Ball collection. Male and female paratypes in author's collection.

Ballana mana n. sp.

Resembling *seca* in form and general appearance but with distinct genitalia. Length 5–5.5 mm.

Vertex broadly rounded, almost twice as long between eyes at base as median length. Margin thick, rounded to front.

Color: Vertex and scutellum dull yellow, pronotum and elytra dull greenish.

Genitalia: Female last ventral segment with side margins sloping and narrowed to posterior margin which is broadly, squarely emarginate one-fourth the distance to base. Male plates short, not as long as combined basal width, sides convexly rounded, apices rather broad, bluntly rounded, not reaching posterior spines by at least half their length.

Described from two male and one female specimens collected at Mojave, California, July 1, 1931, by E. D. Ball. Holotype male and allotype female in Ball collection. Male paratype in author's collection.

Ballana bicornis n. sp.

Resembling *atridorsum* in general appearance, bright green with distinct genitalia. Length 5.5 mm.

Vertex broad, bluntly angled, about one-third wider between eyes than length at middle.

Color: Vertex, pronotum and scutellum yellow, disc of pronotum green. Elytra bright green veins paler.

Genitalia: Female last ventral segment narrowed to apical margin which is broadly roundedly, almost squarely excavated one-fifth the distance to base. Male plates about equal in length to combined basal width, side margins slightly convexly rounded, apices bluntly pointed, not reaching posterior spines.

Described from two male and one female specimens from Logan Mt., Utah, July 22, 1930, (DeLong); one female, Sardine Canyon, Utah, July 28, 1930, (DeLong); one female, Nampa, Idaho, July 12, 1930, (DeLong); five male and five female specimens from Santa Margarita, California, June 23, 1931, (Ball); a male and a female from Yosemite, California, June 21, 1931, (Ball). Holotype male, allotype female (Logan Mt., Utah) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana velosa n. sp.

Resembling *bicornis* in general appearance but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, not quite twice as wide between eyes as length at middle; margin thick.

Color: Vertex pronotum and scutellum pale yellow, disc of pronotum dark green. Elytra dark green, apices subhyaline.

Male plates slightly longer than basal width, side margins slightly, convexly rounded, apices bluntly rounded, not reaching posterior spines by about one-fourth their length.

Described from two male specimens collected at Murtaugh, Idaho, June 21, 1930, (DeLong). Holotype male and paratype male in author's collection.

Ballana antlera n. sp.

Resembling *velosa* in form and general appearance but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, not quite twice as wide between eyes as length at middle. Margin thick.

Vertex, scutellum and anterior portion of pronotum yellow, part of pronotum and elytra dull green.

Genitalia: Female last ventral segment with lateral margins strongly convexly rounding to form outer rounded lobes between which the posterior margin is broadly excavated about one-fourth the distance to the base. Male plates about as long as combined basal width, sides almost straight, apices broad and bluntly rounded, almost one-third their basal width, not reaching posterior spines by about one-fourth their length.

Described from a pair of specimens collected at Murtaugh, Idaho, June 21, 1930, by the author. Male holotype and female allotype in author's collection.

Ballana aris n. sp.

Resembling *velosa* in form and general appearance but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, not quite as wide between eyes at base as length at middle. Margin thick.

Color: Dull green, vertex and scutellum yellowish.

Genitalia: Female last ventral segment with lateral margins obliquely sloping to form bluntly rounded lobes between which the posterior margin is broadly excavated about one fourth the distance to base. Male plates not quite as long as combined basal width, sides almost straight, apices bluntly pointed, not reaching to posterior spines.

Described from a male specimen from Rosette, Utah, June 28, 1929, Knowlton; and a pair of specimens from Kelsaw Canyon, Idaho, collected September 2, 1925, Haegele. Holotype male, allotype female (Kelsaw Canyon, Idaho) and female paratype in author's collection.

Ballana dena n. sp.

In form and general appearance resembling *velosa* but with distinct genitalia. Length 5 mm.

Vertex bluntly angled, not quite twice as wide between eyes at base as length at middle.

Color: Dull grayish green, unmarked.

Genitalia: Male plates not as long as combined width at base, apices more than two-thirds the width at base, blunt, broadly rounded, almost truncate.

Described from a single male specimen from Santa Barbara, California, May, 1918. Holotype male in author's collection.

Ballana calipera n. sp.

Resembling *velosa* in form and general appearance but with distinct genitalia. Length 6 mm.

Vertex bluntly angled, not quite twice as wide between eyes at base as length at middle.

Color: Vertex pronotum and scutellum yellow, disc of pronotum and elytra dark green.

Genitalia: Female last ventral segment with lateral margins strongly convexly rounding to posterior margin which has a rounded outer lobe either side of a central half which is excavated one-fifth the distance to the base, the central portion of which is gently convexly rounded. Male plates about as long as combined basal width, apices blunt, rounded, not reaching posterior spines by about one-fourth their length.

Described from five male and six female specimens collected at Logan Canyon, Utah, July 24, 1930, (DeLong); one female and three male specimens, Tahoe National Park, California, August 6, 1930, (DeLong); four males, Craters of the Moon, Idaho, June 29, 1930, (DeLong); three female specimens, Colfax, California, August 7, 1930; two males, Glendale, Nevada, May 5, 1929, (Fox); one male, Overton, Nevada, June 6, 1930, (Davis); one male, St. George, Utah, June 4, 1930, (Davis); and four male and three female specimens, Medford, Oregon, June 26, 1934, (Ball). Holotype male and allotype female (Logan Canyon, Utah) and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Ballana chelata n. sp.

Resembling *titusi* in form and appearance but with distinct genitalia. Length 5 mm.

Vertex produced and angled, about one-fifth wider between eyes than length at middle, vertex bluntly angled with front.

Color: Vertex yellow, pronotum, scutellum and elytra green, veins paler, apex subhyaline.

Genitalia: Female last ventral segment rather long, lateral margins strongly convexly rounded to produce outer lobes on last ventral segment between which the central third is slightly excavated, the basal margin of excavation slightly convexly rounded. Male plates a little longer than combined basal width, sides almost straight, apices bluntly pointed, not reaching posterior spines.

Described from two female and one male specimens collected at Pacific Grove, California, Aug. 17, 1930, (DeLong); and two male and three female specimens from Muir Woods, California, June 17, 1934, (Ball). Holotype male and allotype female (Pacific Grove, California) and female paratype in author's collection. Male and female paratype' in Ball collection.

Ballana callida n. sp.

Resembling *chelata* in form and general appearance but with distinct genitalia. Length 5–5.5 mm.

Vertex strongly produced and angled, about one-fifth wider between eyes than length at middle and acutely angled with face.

Color: Vertex yellowish, pronotum, scutellum and elytra green tinged with yellow. Elytra with apical cells black.

Genitalia: Female last ventral segment with side margins sloping, narrowed to posterior margin which is broadly squarely and rather shallowly notched two-thirds its width. Male plates about as long as combined width at base, sides straight, apices bluntly pointed, not reaching to posterior spines.

Described from two male and two female specimens collected at Riverside, California, June 13, 1931, and a male from Alpine, California, collected July 5, 1931, all by Dr. E. D. Ball. Holotype male, allotype female and male paratype in Ball collection. Male and female paratypes in collection of the author.

Ballana repa n. sp.

Resembling *angula* in form and general appearance but with distinct genitalia. Length 5–5.5 mm.

Vertex produced but broadly rounded, twice as wide between eyes at base as median length. Margin thick rounded to front.

Color: Yellowish, tinged with green on pronotum, scutellum and elytra.

Genitalia: Female last ventral segment convexly roundedly produced from base to form a narrow posterior margin about half the width of segment which is truncate. Male plates a little longer than combined width at base, side margins concave at middle, apices bluntly rounded, not quite reaching posterior spines.

Described from a male and three female specimens collected at Yuma, Ariz., April 14, 1933, by E. D. Ball. Holotype male, allotype female and female paratype in Ball collection. Female paratype in author's collection.

Ballana latula n. sp.

Female resembling *vapida*, male greenish and with distinct genitalia. Length 6.5 mm.

Vertex broadly, very bluntly angled, twice as wide between eyes at base as median length, sharply angled with front.

Color: Female pale brown on vertex and scutellum. Pronotum and elytra dark brown flecked with yellow, apical veins yellow. Male vertex yellowish, pronotum, scutellum and elytra bright green, apices of elytra smoky.

Genitalia: Female last ventral segment broken but appearing truncate or slightly emarginate. Male plates one-fourth longer than combined width at base, convexly rounded apical fourth more rapidly tapered to form bluntly pointed tips which are produced about as long as anal tubes.

Described from one female and three male specimens collected at Weed, California, June 27, 1934, by E. D. Ball. Holotype male, allotype female and male paratype in Ball collection. Male paratype in author's collection.

Ballana paridens n. sp.

Resembling *vapida* in appearance and coloration but with distinct genitalia. Length 6 mm.

Vertex produced but bluntly angled, about one and two-thirds times as wide between eyes as length at middle.

Color: Brownish tinged with yellow, face with a series of conspicuous arcs broken at middle. Vertex pale brownish, reflexed arcs of face usually visible on margin from above. A pair of faint spots just above apex and a longitudinal stripe on disc either side, darker. Pronotum dark brown, paler on anterior margin. Elytra dark brown irrorate with yellow, veins yellow.

Genitalia: Female last ventral segment narrowed at base, lateral margins produced to posterior margin which is broadly, rather shallowly but squarely excavated and heavily black margined. Male plates about as long as combined basal width, sides concavely rounded. Apices rather broad, rounded, not reaching posterior spines by more than one-third their length.

Described from a series of four male and four female specimens collected at Pine Valley, California, July 6, 1931, by Dr. E. D. Ball. Holotype male, allotype female and male and female paratypes in Ball collection. Male and female paratypes in author's collection.

Ballana latera n. sp.

In form and appearance resembling *dissimilata* but with distinct genitalia. Length 6.5 mm.

Vertex bluntly angled, more than one and one-half times as wide between eyes at base as median length. Margin acutely angled with front.

Color: Vertex tawny, ocelli black, recurved arcs from front visible from above on margin of vertex. Pronotum, scutellum and elytra dull greenish, washed with yellow, veins yellowish.

Male plates about as long as combined basal width, triangular, sides slightly concave at middle, apices bluntly pointed, not reaching posterior spines by at least one-third their length.

Described from a single male specimen collected at Santa Margarita, California, June 25, 1909, by E. D. Ball. Holotype male in Ball collection.

Ballana arma n. sp.

In coloration resembling *dissimilata* but smaller with blunter vertex and with distinct genitalia. Length 6.5–7 mm.

Vertex broad, scarcely produced, bluntly angled, about one-half wider between eyes at base than length at middle.

Color: Male green, female brown. In both sexes the vertex is yellowish with reflexed arcs of face visible on margin from above. In male, pronotum green with yellowish anterior margin, elytra green with paler veins. Female pronotum brown with paler margin, elytra dark brown with paler veins.

Genitalia: Female last ventral segment only two-thirds as wide at base as previous segment, gradually narrowed to posterior margin which is broadly rather shallowly excavated between prominent angles. Male plates not quite as long as combined basal width, sides concavely rounded at middle, apices rather broad, bluntly rounded, not reaching posterior spines by half their length.

Described from two male and two female specimens collected at Yarnell Heights, Arizona, June 21, 1935, by Dr. E. D. Ball. Male holotype and female allotype in Ball collection. Male and female paratypes in author's collection.

BOOK NOTICES

The Origin of Higher Categories in Cynips

This scientific volume is a taxonomic study of 70 new species belonging to the genus Cynips. It is the second volume published by the author on the genus, the first being published in 1930. Most of the new species are from Guatemala and Mexico. Additional information concerning certain species mentioned in the first volume has been added to the second volume. An excellent evolutionary discussion precedes the descriptions. The author has taken the higher categories which were established for the diverging ends of the evolutionary lines in the United States and united them with the existing Mexican species and thus has endeavored to throw light on the origin of higher categories in general. The discussion begins with current concepts of higher categories, followed by modern phylogenetics and the nature and origin of higher categories in Cynips. The author shows that these complexes of species or higher categories are artificial conventions useful for cataloguing biologic data, but are hardly real either in manner of origin or in their intrinsic qualities. He defines higher categories as arbitrarily limited groups of related species in a phylogenetic chain. The content of the volume indicates years of collecting in the field and intensive thought and study of material in the laboratory. Such studies are greatly needed. A bibliography and index are included.—R. H. DAVIDSON.

The Origin of Higher Categories in Cynips, by Alfred C. Kinsey. 334 pp., 172 figs. Bloomington, Indiana University Publications, Science Series No. 242. (Sold by Indiana University Bookstore.) 1936. $2.50.

Photography

"New Ways in Photography" reads like a novel. The book creates in the mind of the reader an enthusiasm for photography as a hobby. A great deal of information on how to produce unusual pictures may be found in the various chapters. The titles of the chapters indicate the refreshing style of the text matter. These are: "Candid" camera capers, The good side of bad weather, After the sun goes down, "Flash, you're it," The family heirs, Hails and farewells, As the worm and bird see it, Remote control, Transparencies, Photomurals and photowallpaper, Effects with filters, Two simple three-color-processes, Photographic multiplication, The long and short of it, "Jest Foolin," Table top trickery, Potpourri, How the professional gets around it, The mending basket, Your own salon, Now it's up to you, Formulary, Index.

This book is not the usual type of reference book nor is it an orderly compendium of methods and facts, yet it contains much unusual and unique information for the amateur who takes his hobby seriously. It will make a worthwhile addition to a personal library.—A. PETERSON.

New Ways in Photography, by Jacob Deschin. 307 pp., illustrated. New York, McGraw-Hill Book Co., 1936. $2.75.

A New General Zoölogy

In his new (1937) text in the field of general zoölogy Professor Lindsey offers something which is different in the way of organization and treatment. The arrangement is not based upon the usual one of taxonomic sequence but upon generalized areas of subject matter. The book is divided into six parts, as follows:

Part I, "The Foundations of Life," proceeds from a historic approach to a consideration of the general character and organization of living matter. Part II, "The Organization and Classification of Animals," is largely the usual descriptive treatment of the phyla in evolutionary order and supposed relationship. Part III, "The Maintenance of the Individual," deals with metabolic processes using examples and illustrations from all parts of the animal kingdom. The relations of organisms with their environment and the interchanges of materials are especially emphasized. Part IV, "The Maintenance of the Species," covers reproduction in general as well as embryology and heredity. Part V, "Problems of Origin," includes the theories and evidences of evolution. Part VI, "Biology and Human Life," gives special attention to the origin of man, the development of his cultures and the consideration of his social problems in the light of biology. This treatment is unusual and much to be commended.

Each of these subject groupings is treated in a comprehensive scholarly fashion sufficient to satisfy the requirements of an exacting general course. The text is quite readable even though a little heavy with technical terminology. The numerous illustrations are unusually good and appropriate. In some instances the author arouses curiosity by general statements without satisfying the curiosity by concrete examples. This may not be a fault if it stimulates the student to seek further knowledge from additional sources. There is also the prevalent tendency toward teleological explanation, but there is not enough of this to detract materially from the accuracy of the factual statements.

The book is good and deserves consideration wherever a course in general college zoölogy is offered. There is a fairly extensive glossary, a good index and a list of one hundred reference books with names of publishers and dates and a brief comment upon the contents of each book. The volume is convenient in size, and pleasingly as well as substantially bound.—D. F. MILLER.

The Science of Animal Life, by Arthur Ward Lindsey. xi+656 pp. New York, Harcourt, Brace and Co., 1937. $3.75.

Psychology

Writing from the point of view of a self-styled "old fashioned psychologist" and consequently holding that a "study of consciousness comprises a very important part of the field of psychological study," the author has produced a text book consisting of five parts, covering twenty-two chapters. Introducing his point of view with a definition of psychology and a brief history of the field, the author launches at once, in the second part of the book, into a discussion of the "simpler conscious processes"—more correctly designated, perhaps, as the sense fields. In logical order "complex conscious processes" follow in the third part. It is interesting to note that the material embodied under the simpler and complex conscious processes absorbs approximately fifty per cent of the total content of Fernberger's book.

Part IV, assigned the general and somewhat inclusive title "Reaction," contains a heterogeneous series of chapters on the nervous system, reflex, instinct, emotion, volition, and habit. Finally, in Part V, the "integrated organism" has its moment, wherein drive and motivation, individual differences, and integrated personality receive a sketchy treatment.

The author has apparently striven for a logical order of presentation which is altogether artificial and which adds nothing to the clarity or comprehensibility of his position. For instance, it seems of questionable validity to include **thinking** under **complex conscious processes** and **habit** under **reaction.** Further, it is difficult to understand why **learning** has been ignored as a special category. Insignificant attention has been devoted to social behavior, child development, and more recent aspects of measurement. Topics which do receive major emphasis are not far removed from the classical laboratory. By and large, if the objective of psychology is to be that of allegedly "pure science," then likely Fernberger's work fulfills most requirements. If, however, pragmatic emphasis is the order of the day in the development of scientific psychology, then the author's book has not moved a very great distance from the strictly conventional approach of the older school.—M. A. DUREA.

Elementary General Psychology, by Samuel W. Fernberger. xxii+445 pp. Baltimore, the Williams and Wilkins Co., 1936. $3.00.

Raising Invertebrates

For a number of years biological scientists have wished for a publication that would bring together the better known methods on how to rear various invertebrate animals. In large measure this wish has been fulfilled in the new book entitled "Culture Methods for Invertebrate Animals." The committee in charge of this publication, J. G. Needham (Chairman), P. W. Galtsoff, F. E. Lutz, P. S. Welch, and its secretary Mary E. Davis, have assembled a valuable series of original articles and compilations on collecting and rearing methods for invertebrate animals. The committee is to be congratulated on completing its job in such an effective manner.

In this book an attempt is made to include rearing information on all groups (usually families) of invertebrates, by presenting detailed information on one or more representatives in each group. Naturally the Arthropods occupy the greater portion of the book, covering over 300 pages. The aquatic species among the various groups are discussed and treated extensively and intensively. Among the insects a number of important groups and species are omitted. In some instances, however, the information presented on closely related groups will be of assistance. A more extensive presentation of detailed figures of the equipment employed in rearing would have added considerably to the value of the book.

A work of this character should stimulate investigators to make careful and detailed reports on the methods they pursue in rearing invertebrates. Undoubtedly many valuable methods have not been published and it is hoped that they will make their appearance in the near future, so they may be included in future revisions. This book will make a valuable addition to any private or public biological library.—A. PETERSON.

Culture Methods for Invertebrate Animals, by a committee of American Zoologists from Section F. of A. A. A. S. xxxii+590 pp., 84 figs. Ithaca, New York, Comstock Publishing Company, 1937. $4.00.

Biological Control

The author of the first book in the English language on biological control of insects has compiled an interesting introduction to this subject. This volume provides a general text and much valuable information for beginning students and for those desiring general information.

For advanced students and investigators in biological control the book does not fulfill the decided need for a source book of knowledge. A volume (or volumes) of this nature can only be prepared by one or more investigators who have had many years of research and practical experience and have a broad viewpoint of the entire subject. One should not expect this volume to be a thorough and comprehensive treatise for the author has had very little practical experience in biological control. Also, so far as is known, the author has not published any original research in this field.

Many investigators in the field of biological control will not agree with several important definitions presented in the book. The chapters (6 and 7) on parasitic Diptera and Hymenoptera, are much too brief in scope and content to be of very great value to students or investigators. One of the unfortunate features of the book is the lack of cross references in the text portion. Most of the thoughts and ideas expressed in the various chapters have been stated by the investigators listed in the references at the end of the book. The author should have indicated the source of these ideas, especially where the same phraseology is used. A short glossary and a list of references occur at the end of the book.—A. PETERSON.

The Biological Control of Insects, by H. L. Sweetman. viii+454 pp. Ithaca, the Comstock Publishing Co., 1936. $3.75.

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INDICATION OF UNIT FACTOR INHERITANCE IN DATA COMPRISING BUT A SINGLE GENERATION

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It has been shown by Penrose (1935) that linkage between two autosomal unit characters can be detected and measured through the investigation of randomly collected pairs of brothers and sisters of unspecified parentage. This discovery promises to be of great assistance to university laboratories and similar institutions where parents are secured with difficulty. It should also prove of interest if from data of the same sort it were possible to test the hypothesis of unit factor inheritance for any human trait, and it would seem worth while, in this event, to apply such a test to both traits under investigation before proceeding with the analysis of linkage between them. Such a test, it is thought, may be accomplished by the methods to be described in this note.

Let us suppose that two characters, which we shall simply designate (+) and (−), are thought to be determined by a single pair of autosomal genes, T and t, with (+) being the dominant character. Randomly collected sibships whose parents have not been ascertained may readily be classified as to their composition and the number of each sort recorded. Now, if the population be assumed at equilibrium with respect to the distribution of genes T and t, a condition which must necessarily follow the occurrence of random mating, we may then estimate the frequencies of the two alleles. From these we may calculate the expected frequencies of the various sorts of sibship and measure the discrepancy between calculated and observed values by the usual Chi-square (χ^2) test.

USE OF SIB-PAIRS

One procedure, which has the advantage of entailing a minimum of calculations, consists in the classification of all sib-pairs contained in the available sibships of larger size and adding these numbers to those obtained from sibships of only two members. In general, a sibship of s members must supply $^sC_2 = s(s-1)/2$ sib-pairs.’ However, since a χ^2-test of sibships in which the expected number in any class is less than 5 must suffer considerable inaccuracy, it is therefore advisable to exclude sibships of such sizes, rather than allow these to contribute to the three classes of sib-pairs.

Designating the frequencies of genes T and t by p and $(1-p)$, respectively, the expected proportions of sib-pairs having 0, 1, and 2 members showing the (+) character may be deduced by application of the principle of random mating as is shown in Table I. The expectations in the three classes are found by summing the terms in the extreme right-hand column for each type of sib-pair. In a sample of n_2 sib-pairs the expected frequencies of sib-pairs having 0, 1, and 2 (+) members are therefore, respectively,

TABLE I

Type of Sib-pair	Possible Genotypes of Parents	Proportional Frequency of Mating	Probability of Sib-pair	Expected Proportion of Sib-pairs
Both (—)	Tt × Tt	$4p^2(1-p)^2$	$\frac{1}{16}$	$\frac{1}{4}p^2(1-p)^2$
(tt, tt)	Tt × tt	$4p(1-p)^3$	$\frac{1}{4}$	$p(1-p)^3$
	tt × tt	$(1-p)^4$	1	$(1-p)^4$
(+) and (—) (TT, tt) or	Tt × Tt	$4p^2(1-p)^2$	$\frac{6}{16}$	$\frac{3}{2}p^2(1-p)^2$
(Tt, tt)	Tt × tt	$4p(1-p)^3$	$\frac{1}{2}$	$2p(1-p)^3$
Both (+)	TT × TT	p^4	1	p^4
(TT, TT) or	TT × Tt	$4p^3(1-p)$	1	$4p^3(1-p)$
(TT, Tt)	TT × tt	$2p^2(1-p)^2$	1	$2p^2(1-p)^2$
or	Tt × Tt	$4p^2(1-p)^2$	$\frac{9}{16}$	$\frac{9}{4}p^2(1-p)^2$
(Tt, Tt)	Tt × tt	$4p(1-p)^3$	$\frac{1}{4}$	$p(1-p)^3$

$$\left.\begin{aligned} f_{20} &= \tfrac{1}{4}(1-p)^2(2-p)^2 n_2, \\ f_{21} &= \tfrac{1}{2}p(1-p)^2(4-p)n_2, \\ \text{and}\quad f_{22} &= \tfrac{1}{4}p(4+5p-6p^2+p^3)n_2. \end{aligned}\right\} \qquad \ldots\ldots\ldots(1)$$

The most convenient means of obtaining an estimate of p is by employing the observed proportions of (+) and (−) individuals in the aggregate of the sibships used in the χ^2-test. The expected proportions of (+) and (−) individuals under random mating are $1-(1-p)^2$ and $(1-p)^2$, respectively, and if the corresponding observed proportions are A and B, we may then take

$$p = 1 - \sqrt{B}. \qquad \ldots\ldots\ldots(2)$$

Using this estimate we may calculate the expected frequencies (1) of the three sib-pair types and compare these with the observed numbers by the method of Chi-square. The number of degrees of freedom to use in entering a probability table of χ^2 values is one (1) in this case, in accordance with the fact that the expected values are adjusted so as to conform with the observed series in two respects—the total number, n_2, and the parameter, p.

TABLE II

Type of Sibship	Possible Genotypes of Parents	Proportional Frequency of Mating	Probability of Sibship	Expected Proportion of Sibships
All s (—) s(tt)	Tt × Tt	$4p^2(1-p)^2$	$(\frac{1}{4})^s$	$4(\frac{1}{4})^s p^2(1-p)^2$
	Tt × tt	$4p(1-p)^3$	$(\frac{1}{2})^s$	$4(\frac{1}{2})^s p(1-p)^3$
	tt × tt	$(1-p)^4$	1	$(1-p)^4$
r (+), s-r (—) r(TT,Tt) s-r(tt)	Tt × Tt	$4p^2(1-p)^2$	${}^sC_r(\frac{3}{4})^r(\frac{1}{4})^{s-r}$	$4\,{}^sC_r(\frac{3}{4})^r(\frac{1}{4})^{s-r}p^2(1-p)^2$
	Tt × tt	$4p(1-p)^3$	${}^sC_r(\frac{1}{2})^s$	$4\,{}^sC_r(\frac{1}{2})^s p(1-p)^3$
All s (+) s(TT,Tt)	TT × TT	p^4	1	p^4
	TT × Tt	$4p^3(1-p)$	1	$4p^3(1-p)$
	TT × tt	$2p^2(1-p)^2$	1	$2p^2(1-p)^2$
	Tt × Tt	$4p^2(1-p)^2$	$(\frac{3}{4})^s$	$4(\frac{3}{4})^s p^2(1-p)^2$
	Tt × tt	$4p(1-p)^3$	$(\frac{1}{2})^s$	$4(\frac{1}{2})^s p(1-p)^3$

USE OF SIBSHIPS OF LARGER SIZE

A more extensive treatment of the data might be undertaken by comparing the observed frequencies of the various sorts of trios, quartettes, quintettes, etc., with the frequencies expected under random mating. In general, for sibships of size s, the expected proportions of each of the (s+1) different sorts may be derived as shown in Table II. The expected frequencies in the three classes indicated in the table are found by summing the terms in the right-hand column for each class and multiplying by n_s, the observed number of sibships of s. The expected number of sibships having all s members of the (+) type is

$$f_{ss} = \{p^4 + 4p^3(1-p) + (2+3^s4^{1-s})p^2(1-p)^2 + 2^{2-s}p(1-p)^3\}n_s, \qquad \ldots\ldots\ldots(3)$$

and the expected number having no (+) members is

$$\begin{aligned} f_{s0} &= \{4^{1-s}p^2(1-p)^2 + 2^{2-s}p(1-p)^3 + (1-p)^4\}n_s \\ &= \left\{(1-p)\left[1-p\left(\frac{2^{s-1}-1}{2^{s-1}}\right)\right]\right\}^2 n_s, \qquad \ldots\ldots\ldots(4) \end{aligned}$$

while for the remaining (s−1) types, the expectations can be calculated from the expected number of sibships having r (+) and s−r (−) members,

$$\begin{aligned} f_{sr} &= \{4\,{}^sC_r(3/4)^r(1/4)^{s-r}p^2(1-p)^2 + 4\,{}^sC_r(1/2)^s p(1-p)^3\}n_s \\ &= {}^sC_r\,p(1-p)^2\left\{p\,\frac{3^r}{4^{s-1}} + (1-p)\,\frac{1}{2^{s-2}}\right\}n_s, \qquad \ldots\ldots\ldots(5) \end{aligned}$$

which is general except for the cases, r = 0 and r = s.

TABLE III

Polynomials for Computing the Expected Proportions of Various Sibship Classes

Class		Coefficient of				
s	r	1	p	p^2	p^3	p^4
2	0	4	—12	13	—6	1
2	1		8	—18	12	—2
2	2		4	5	—6	1
3	0	16	—56	73	—42	9
3	1		24	—63	54	—15
3	2		24	—45	18	3
3	3		8	35	—30	3
4	0	64	—240	337	—210	49
4	1		64	—180	168	—52
4	2		96	—234	180	—42
4	3		64	—84	—24	44
4	4		16	161	—114	1
5	0	256	—992	1441	—930	225
5	1		160	—465	450	—145
5	2		320	—870	780	—230
5	3		320	—690	420	—50
5	4		160	—75	—330	245
5	5		32	659	—390	—45

Expressions (3), (4), and (5) are polynomials in p of the 4th degree. For the purpose of simplifying calculations the coefficients of each term have been computed and set out in Table III for the various sorts of sibships of 2, 3, 4, and 5 members. The expected frequency in any class may be found by summing the terms containing the appropriate coefficients, dividing the sum by the quantity, $2^{2(s-1)}$, and multiplying by the total number of sibships of that size. For example, the expected number of trios having 1 (+) member and 2 (−) members is

$$f_{31} = \frac{n_3}{16}(24p - 63p^2 + 54p^3 - 15p^4).$$

Separate estimates of p may be calculated from the proportions of (+) individuals among sibships of each size or a single estimate may be obtained from the proportion found among sibships of all sizes. In the first case, a χ^2-test of sibships of size s will involve $s-1$ degrees of freedom and χ^2 may thus be calculated for each size of sibship separately. When a single value of p is used χ^2 may be calculated for the entire data and the number of degrees of freedom will be one less than the sum of all values of s.

ALTERNATIVE HYPOTHESES

An important limitation of the method described above is the fact that, except for very extensive data, it should not generally be possible to distinguish whether (+) or (−) is actually the dominant trait, even when the hypothesis of unit factor inheritance has been confidently established. This may be demonstrated in a general way as follows: If, instead of assuming (+) to be the dominant character as in the above analysis, we should assume (+) to be the recessive trait, than we might estimate the frequency of the dominant gene as

$$p' = 1 - \sqrt{A}, \qquad \ldots\ldots\ldots(6)$$

and the expected frequencies of sibships of 0, 1 and 2 (+) members would then be the reverse of those given in (1), that is,

$$\left.\begin{aligned} f'_{20} &= \tfrac{1}{4}p'(4+5p'-6p'^2+p'^3)n_2,\\ f'_{21} &= \tfrac{1}{2}p'(1-p')^2\,(4-p')n_2,\\ f'_{22} &= \tfrac{1}{4}(1-p')^2\,(2-p')^2 n_2, \end{aligned}\right\} \qquad \ldots\ldots\ldots(7)$$

or, substituting the estimate p' given by (6),

$$\left.\begin{aligned} f'_{20} &= \{1-\tfrac{1}{2}A(1-\sqrt{A})\,(3+\sqrt{A})-\tfrac{1}{4}A(1+\sqrt{A})^2\}n_2, \\ f'_{21} &= \tfrac{1}{2}A(1-\sqrt{A})\,(3+\sqrt{A})n_2, \\ f'_{22} &= \tfrac{1}{4}A(1+\sqrt{A})^2 n_2. \end{aligned}\right\}\ldots(8)$$

These are to be compared with

$$\left.\begin{aligned} f_{20} &= \tfrac{1}{4}(1-A)\,(1+\sqrt{1-A})^2 n_2, \\ f_{21} &= \tfrac{1}{2}(1-A)\,(1-\sqrt{1-A})\,(3+\sqrt{1-A})\,n_2, \\ f_{22} &= \{1-\tfrac{1}{2}(1-A)\,(1-\sqrt{1-A})\,(3+\sqrt{1-A})-\tfrac{1}{4} \\ &\qquad (1-A)\,(1+\sqrt{1-A})^2\}n_2, \end{aligned}\right\}\ldots(9)$$

the values expected where (+) is dominant, found by putting $p=1-\sqrt{1-A}$ in the expressions in (1).

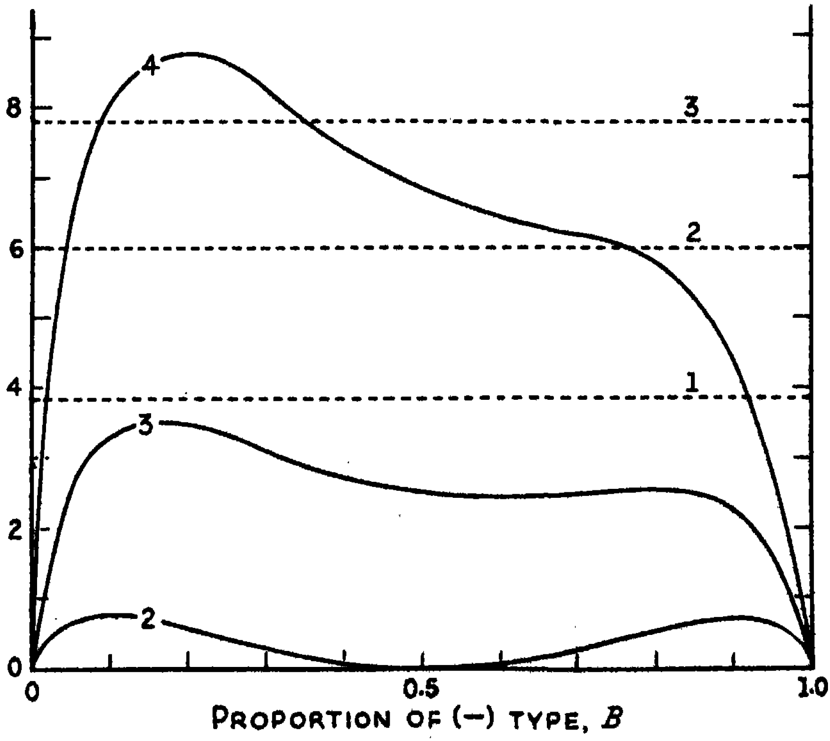

FIG. 1. Expected values of χ^2 as a measure of discrepancy between sibship expectations under the assumptions of dominance of (+) and of (−) types, calculated on the basis of 100 sibships each of 2, 3, and 4 sibs. Compare with the 5 per cent levels of significance for 1, 2, and 3 degrees of freedom, shown by broken lines.

We may get some idea as to the relative chances of eliminating the hypothesis of dominance for the (−) trait by assuming the observed frequencies to be consistent with the expectations of dominance for the (+) trait and by calculating the expected value of χ^2 as a measure of the discrepancies between corresponding expectations under the two hypotheses. The quantity,

$$\chi^2 = S\left\{\frac{(f'\mathrm{sr} - f\mathrm{sr})^2}{f'\mathrm{sr}}\right\},$$

is plotted in Figure 1 for values of B from 0 to 1 and for sibships of two, three, and four members, using 100 sibships of each size. The results show that sibships of larger size are more valuable in attempting to discriminate between the two hypotheses, but that considerably larger numbers should be available even in these cases.

TABLE IV

Expected values of χ^2 as a measure of discrepancy between sib-pair expectations under the assumptions of unit factor inheritance with (+) as the dominant trait and of non-genetic chance determination, calculated on the basis of 100 sib-pairs.

Proportion of (—) type, B	χ^2	Proportion of (—) type, B	χ^2
0	0	0.6	21.89
0.1	13.77	0.7	22.95
0.2	16.40	0.8	23.64
0.3	18.29	0.9	24.34
0.4	19.76	1.0	0
0.5	20.92		

In the investigation of a trait heretofore unstudied from the genetic standpoint it might be desirable to eliminate, if possible, another hypothesis, namely, that the difference between (+) and (−) types is attributable to chance agencies in which biological relationship plays no part. Under this supposition, however, we should expect the various sorts of sibships of s to occur with frequencies which are the terms in the expansion of the binomial,

$$(A+B)^s n_s.$$

Comparing these expectations with those based upon the assumption of unit factor inheritance by calculating χ^2 as before we have the values listed in Table IV, in which 100 sibships of two members are assumed to be available. The table shows that we may be quite confident of eliminating an hypothesis of non-genetic chance determination if the data are, in fact, consistent with expectations under the hypothesis of unit factor inheritance.

APPLICATION TO DATA ON "P. T. C." TASTE DEFICIENCY

For the purpose of illustrating the χ^2-test of sibships by a numerical example, we may test a body of data on phenylthiocarbamide taste deficiency. Crystals of "P. T. C." were used in making these tests, and most of the families recorded consisted of sibs whose parents were not tested. Utilizing those families in which both parents were tested, however, we may, as a preliminary measure, test the hypothesis of random mating with respect to this character. A simple procedure for this purpose consists in the use of a two-by-two table in which members of either sex are classified as to their own taste reactions and as to the taste reactions of their mates. A significant deviation from proportionality in the four combination classes may then be taken as indicative of assortative mating or the absence of random mating.

Since ability to taste has previously been shown (Blakeslee and Salmon, 1931; Snyder, 1931) to be the dominant trait, we may designate tasters by (+) and non-tasters by (−). In the 78 families having both parents tested the observed frequencies of the four parental combinations are as shown in the following table:

TABLE V

	husbands		total
	+	−	
wives +	43	17	60
wives −	13	5	18
total	56	22	78

The entries are almost exactly proportional to the marginal frequencies as should be expected under random mating. The value expected in the class in which both parents are non-tasters is $(22 \times 18)/78 = 5.077$. Calculation of the probability of a departure from expectation equal to or greater than the one observed is as follows (cf. Fisher, p. 99): The observed set of entries and those more extreme in their deviation from proportionality in the same direction are

$$\begin{bmatrix} 43 & 17 \\ 13 & 5 \end{bmatrix}, \begin{bmatrix} 42 & 18 \\ 14 & 4 \end{bmatrix}, \begin{bmatrix} 41 & 19 \\ 15 & 3 \end{bmatrix}, \begin{bmatrix} 40 & 20 \\ 16 & 2 \end{bmatrix}, \begin{bmatrix} 39 & 21 \\ 17 & 1 \end{bmatrix}, \begin{bmatrix} 38 & 22 \\ 18 & 0 \end{bmatrix},$$

and their respective probabilities are

$$\left(\frac{60!18!56!22!}{78!}\right) \left(\frac{1}{43!17!13!5!}, \frac{1}{42!18!14!4!}, \frac{1}{41!19!15!3!}, \frac{1}{40!20!16!2!}, \frac{1}{39!21!17!}, \frac{1}{38!22!18!}\right),$$

or, 0.2341, 0.1998, 0.1177, 0.0453, 0.0101, 0.0010. The observed set of entries is therefore to be expected by chance in over 23 per cent of trials and deviations from proportionality in the direction observed of equal or greater magnitude should be obtained in as much as 60 per cent of trials. The assumption of random mating is thus highly justified.

TABLE VI

Numbers of cases of various sibships of 2, 3, and 4 sibs tested for "P. T. C." taste deficiency

Size of Sibship, s	Number of Tasters, r					Totals, n_s
	0	1	2	3	4	
2	11	22	74	..	..	107
3	8	8	16	38	..	70
4	1	5	7	8	16	37

The observed frequencies of the various sorts of sibships of 2, 3, and 4 members are given in Table VI. Larger sibships were also contained in the data but were few in number and no analysis of them shall be attempted.

The total number of tasters in sibships of any size, s, is found by summing the quantity r $(n_{s,r})$ for all values of r. For example, among sib-pairs the total number of tasters is $(0\cdot 11+1\cdot 22+2\cdot 74) = 170$, the total number of individuals among sib-pairs is $sn_s = 2\cdot 107 = 214$, and the proportion of tasters in sibships of 2 is therefore $A = 170/214 = 0.7943925$, giving $\mathrm{p} = 1 - \sqrt{1-A} = 0.5466$. The values of A and p calculated in a similar manner from sibships of 3 and 4 are shown in Table VII.

TABLE VII

Values of A and p indicated by sibships of 2, 3, and 4 sibs

Size of Sibship, s	Total Number of Tasters	Total Number of sibs, sn_s	Proportion of Tasters, A	p ($= 1 - \sqrt{1-A}$)
2	170	214	.7943925	.5466
3	154	210	.7333333	.4836
4	107	184	.7229729	.4737

TABLE VIII

Calculation of the Expected Frequencies

Class		k_0p^0	k_1p^1	k_2p^2	k_3p^3	k_4p^4	$\overset{4}{\underset{i=0}{\mathrm{S}}} k_ip^i$	Expected Frequency $f_{sr} = \frac{n_s}{2^{2(s-1)}} \overset{4}{\underset{i=0}{\mathrm{S}}} k_ip^i$
s	r		p = .5466	$\mathrm{p}^2 = .2988$	$\mathrm{p}^3 = .1633$	$\mathrm{p}^4 = .0893$		
2	0	4	—6.5592	3.8844	—.9798	.0893	.4347	11.6282
2	1		4.3728	—5.3784	1.9596	—.1786	.7754	20.7420
2	2		2.1864	1.4940	—.9798	.0893	2.7899	74.6298
			p = .4836	$\mathrm{p}^2 = .2339$	$\mathrm{p}^3 = .1131$	$\mathrm{p}^4 = .0547$		
3	0	16	—27.0816	17.0747	—4.7502	.4923	1.7352	7.5915
3	1		11.6064	—14.7357	6.1074	—.8205	2.1576	9.4395
3	2		11.6064	—10.5255	2.0358	.1641	3.2808	14.3535
3	3		3.8688	8.1865	—3.3930	.1641	8.8264	38.6155
			p = .4737	$\mathrm{p}^2 = .2244$	$\mathrm{p}^3 = .1063$	$\mathrm{p}^4 = .0504$		
4	0	64	—113.6880	75.6228	—22.3230	2.4696	6.0814	3.5158
4	1		30.3168	—40.8920	17.8584	—2.6208	5.1624	2.9845
4	2		45.4752	—52.5096	19.1340	—2.1168	9.9828	5.7713
4	3		30.3168	—18.8496	—2.5512	2.2176	11.1336	6.4366
4	4		7.5792	36.1284	—12.1162	.0504	31.6398	18.2918

The expected frequencies of the various sorts of sibships of 2, 3, and 4 are calculated in Table VIII. The coefficients, k_0–k_4, are obtained from Table III and the values of p used for each sibship size are those given in Table VII.

Two classes of quartettes (0 and 1 taster) have expected frequencies which are less than 5 and it is customary to combine such classes in the χ^2-test, using one less degree of freedom, as shown in Table IX.

TABLE IX

Calculation of χ^2 for sibships of each size and for the total

Class s r	Observed Frequency, n_{sr}	Expected Frequency, f_{sr}	$\frac{(f_{sr}-n_{sr})^2}{f_{sr}}$	χ^2	Degrees of Freedom	Probability, P
2 0	11	11.6282	.034	.115	1	.74
2 1	22	20.7420	.076			
2 2	74	74.6298	.005			
3 0	8	7.5915	.002	.441	2	.80
3 1	8	9.4395	.220			
3 2	16	14.3535	.189			
3 3	38	38.6155	.010			
4 0, 1	6	6.5003	.039	.968	2	.62
4 2	7	5.7713	.262			
4 3	8	6.4366	.380			
4 4	16	18.2918	.287			
Totals	....	....	....	1.524	5	.92

The observed values conform very closely with the expected series, though not unreasonably so, and the hypothesis of unit factor inheritance with the ability of taste as the dominant character is therefore substantially upheld.

TABLE X

Sib-pairs available in sibships of 2 and 3 sibs

Number of Tasters, r	Sib-pairs in Sibships of 2	Sib-pairs in sibships of 3 in which tasters number				Total, n_{sr}
		0	1	2	3	
0	11	24	8	..	..	43
1	22	..	16	32	..	70
2	74	..	..	16	114	204
Total.....	107	24	24	48	114	317

As an alternative procedure we may take all of the sib-pairs contained in the sibships of 3 and combine the numbers of each type with those obtained from sibships of 2 only. The sibships of 4 are not used in like manner, since the expected numbers in two classes are less than 5. The 8 trios having no (+) members provide 24 pairs having no (+) members, the 8 trios of 1 (+) member provide 8 pairs of no (+) members and 16 pairs of 1 (+) member, etc. The total contributions of sib-trios to the three sib-pair classes are shown in Table X.

The number of tasters in sib-pairs and trios combined is $170+154=324$, as shown in Table VII, among a total number of individuals, $214+210=434$, giving as the proportion of tasters in sibships of 2 and 3 combined the fraction, $A=324/424$, and the value of p indicated by sibships of both sizes is therefore

$$\mathrm{p}=1-\sqrt{1-\frac{324}{424}}=.514357.$$

The expected numbers of sibships having 0, 1, and 2 (+) members are calculated from equations (1), which give

$$f_{20}=41.2535,$$
$$f_{21}=67.0213,$$
$$f_{22}=208.7252.$$

Comparing these with the observed values, 43, 70, and 204, χ^2 is found to be 0.313, which for one degree of freedom should be exceeded by chance in about 60 per cent of trials. The data are again in good agreement with the hypothesis of unit factor inheritance with ability to taste as the dominant trait.

To test the hypothesis that the absence of taste (−) is dominant we may test the sib-pair frequencies obtained from sibships of 2 and 3 in a similar manner, as described in the foregoing section. In this case the expected frequencies as calculated from equations (8) turn out to be

$$f_{20}=45.2394,$$
$$f_{21}=59.0500,$$
$$f_{22}=212.7106,$$

and χ^2 is 2.499. The deviations are greater than those calculated under the assumption of dominance for taste ability but are not significant in themselves. With one degree of freedom one should expect a χ^2 value of 2.499 to be exceeded by chance in 12 per cent of trials. It thus appears impossible to determine from the data whether tasters or non-tasters are dominant by this method, as might have been expected. Unit factor inheritance of one sort or the other, however, may be confidently assumed.

The hypothesis that ability to taste phenyl-thiocarbamide is determined by non-genetic chance agencies can readily be eliminated. The expected frequencies of sib-pairs containing 0, 1, and 2 tasters under this assumption are, respectively,

$$B^2n_2=\left(\frac{100}{424}\right)^2\times 317=17.6347,$$

$$2ABn_2=2\times\frac{324}{424}\times\frac{100}{424}\times 317=114.2595,$$

and
$$A^2n_2=\left(\frac{324}{424}\right)^2\times 317=185.1058.$$

Comparing these with the observed numbers, 43, 70, and 204, χ^2 is found to be 55.558, which for one degree of freedom should be exceeded in far less than once in 1000 trials.

SUMMARY

Randomly collected sibships of unspecified parentage may be classified as to their composition and the expected frequency of each sibship type may be calculated from the total number of sibships of each size and from the proportions of the two types of individuals in such sibships. The observed frequencies may then be compared with the expected values by the method of Chi-square. With small numbers of sibships, however, it will usually be impossible to determine which of the two contrasting characters is actually dominant by such a χ^2-test. If the observed frequencies agree satisfactorily with expectations under an hypothesis of dominance for one character, it may usually be expected that they shall not deviate significantly from expectations under an hypothesis of dominance for the contrasting character. It will usually be possible, however, to eliminate an hypothesis of non-genetic chance determination, if the data are in agreement with the hypothesis of unit factor inheritance.

Applying the χ^2-test to randomly collected sibships tested for taste deficiency to phenyl-thiocarbamide these generalizations are found to hold true. The data are in excellent agreement with the unit factor hypothesis established by Blakeslee and Salmon and by Snyder.

The Chi-square method should be useful as a check of unit factor inheritance in data which are to be analyzed for autosomal linkage by the method of Penrose and as a preliminary genetic test in the case of new reaction differences.

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THE PORTERSVILLE MEMBER OF THE CONEMAUGH FORMATION IN MUSKINGUM COUNTY, OHIO

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The problem on which this paper reports progress concerns the Portersville member of the Conemaugh Formation in Muskingum County. To quote from Condit's bulletin on the Conemaugh Formation in Ohio, the Portersville is usually found as "a black calcareous shale, rich in pyrite and carbonaceous matter and often containing masses of fossils preserved as pyrite. In some places a layer of black nodular limestone overlies the shale, beautifully preserved fossils occur, the fauna being especially rich in minute pelecypods and gastropods."[1] The object of this investigation was to study the fauna to see if there are any significant differences in the fauna found in different localities.

As a result of a field study of the member, collections of fossils were made in eight different localities in this region and carefully studied. In two of these Coal Hollow located in the southwest part of section 22 in Bluerock Township, and Norwich located in the northwest part of section 7 in Union Township about twelve miles north of Coal Hollow, I found the best preserved and most abundant fauna. Therefore more time was spent on these faunas and consequently much of the discussion in this paper will concern these two localities.

These two places had some fossils in common but in many cases the forms which would be abundant in one would not be abundant in the other. The forms which were found to be abundant in both localities are:

Crinoid stems
Chonetes verneuilanus
Derbya crassa

Two of these three forms which are abundant in both localities are the brachiopods, *Chonetes verneuilanus* and *Derbya crassa*, which are fairly abundant throughout the whole region not only in this horizon but in others. There are only two other forms which are found in both localities, a species of *Worthenia* and *Orthoceras rushense;* both of these forms are abundant at

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[1] Condit, Geological Survey of Ohio, Fourth Series Bulletin No. 17, p. 276.

Norwich but scarce at Coal Hollow. Farmers near Coal Hollow digging for underlying Anderson coal report the finding of coiled cephalopods, a species of which I report for Norwich.

The forms which are found at Coal Hollow but which are not reported for the Norwich section are:

Rhombopora lepidodrendroides
Chonetes granulifer
Chonetes granulifer var. *armata*
Productus cora (of authors)
Astartella vera
Edmondia aspenwallensis
Leda bellistriata
Nuculopsis ventricosa
Parallelodon obsoletus
Parallelodon tenuistriatus
Pharkidonotus percarinatus
Plant remains

Of these twelve forms, it is significant that six of them are pelecypods while in the Norwich section there are no pelecypods found at all. Inasmuch as *Chonetes granulifer* and *Chonetes granulifer* var. *armata* have not been reported for this horizon before I shall describe them briefly. The specimens in nearly all cases have been preserved as pyrite or marcasite.

1892. *Chonetes coronata* Conrad, Hall, Nat. Hist. of N. Y. Pal., Vol. VIII, Part I, p. 303, Pl. xvi, figs. 10, 11.

Hamilton group, Darien, N. Y.

1912. *Chonetes granulifer* Owen, Condit, Conemaugh Formation in Ohio, p. 300–301, Pl. XIII, fig. 3.

Ames limestone, New Concord, Ohio.

Chonetes granulifer upon superficial examination could easily be mistaken for *Chonetes verneuilanus*. There are, however, several outstanding differences. *C. granulifer* has a broad, shallow mesial sinus on the pedicle valve, while *C. verneuilanus* has a rather deep mesial sinus on the pedicle valve. Growth lines also seem to be more pronounced on *C. granulifer* than on *C. verneuilanus*. The hinge line of *C. granulifer* appear to be shorter and beak not so elevated as on *C. verneuilanus*. On the whole, *C. granulifer* appears to be somewhat smaller in size than *C. verneuilanus*. The dimensions of an average individual are length of hinge lines, 9 mm. and height, 7 mm.

1915. *Chonetes granulifer* var. *armatus* Girty, Wewoka Formation of Okla., p. 62, Pl. VII, fig. 2-4.

Wewoka formation, Oklahoma.

While I found only two specimens of *Chonetes granulifer* var. *armata*, I think they are distinctive enough to be placed provisionally in this classification. They differ from *C. granulifer* in that they possess numerous small spine bases located in no particular order over the shell but follow roughly the plications running outward from the beak to the edge of the shell. On one specimen there is a fairly pronounced mesial sinus while on the other this sinus is broad and rather shallow as on a true *C. granulifer*. In neither case was the beak as high as that of *Chonetes verneuilanus*. On both specimens the hinge line was extended so that there were little ear-like projections on either end of the hinge line. The dimensions of these specimens were:

hinge line 7 mm.	length 4 mm.
8 mm.	5 mm.

On the other hand, the forms which are found at Norwich constitute a somewhat different type of fauna, which consists of brachiopods and cephalopods instead of brachiopods and pelecypods as at Coal Hollow. These forms which are found at Norwich but not at Coal Hollow are:

Lophophyllum profundum
Ambocoella planoconvexa
Orbiculoidea missouriensis
Spirifer cameratus
Schizostoma catilloides
Orthaceras sp.
Temnocheilus forbesianus

The species *Orthaceras rushense* McChesney is abundant at Norwich but is found only occasionally at Coal Hollow. The form *Ambocoelia planoconvexa* is very abundant here and could be called the dominant form in spite of the fact that it is somewhat undersize as compared with forms taken from other formations.

Between the localities of Coal Hollow and Norwich, there is a locality, the Eckleberry farm, the fossils of which have been reported in Condit's Bulletin on the Conemaugh Formation.[2] This farm is located in section 10 of Bluerock Township, 2½ miles north of Coal Hollow and 12½ miles southwest of Norwich. Here are found twenty-five forms reported, four of which are found in both of the other localities mentioned. These four are:

Crinoid fragments
Derbya crassa
Chonetes verneuilanus
Orthaceras rushense

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[2] Op. cit., pp. 276–277.

SUMMARY OF FAUNAL DISTRIBUTION

	Coal Hollow	Norwich	Section 1	Section 6	Section 8	Section 10	Section 12	Section 13
Lophophyllom profundum		aa	r(?)					
Crinoid stems	a	a	r	r		r	r	a
Rhombopora lepidodendroides	a							
Ambocoelia planoconvexa		aaa				r	r	
Chonetes granulifer	a							
Chonetes granulifer armata	r							
Chonetes verncuilanus	aa	a	r	r				
Derbya crassa	aaa	aa	a	a	a	a	r	a
Orbiculoidea Missouriensis		r						
Productus cora (of authors)	aa							
Spirifer cameratus		r			r(?)			
Astartella vera	r							
Edmondia aspenwallensis	a		r	r	a	a	r(?)	a
Leda bellistriata	a				a			r
Nuculopsis ventricosa	r							
Paralledodon obsoletus	r							
Parallelodon tenuistriatus	a			r	r			
Pharkidonotus percarinatus	a		r	a				
Pleurotomaria carbonaria					r	r(?)	a	
Schizostoma catilloides		r						
Worthenia sp.	r	a	r		r	r		r(?)
Orthaceras sp.		r						
Orthaceras rushense	r	a						
Temnocheilus forbesianus		r						
Plant remains	r							

a = abundant.
aa, aaa = very abundant.
r = rare.
r(?) = questionably present.

Three of the forms found at this section are found only at Norwich but not at Coal Hollow. Six of the forms found are common to both Coal Hollow and the Eckleberry farm but not to Norwich. These forms are ***Rhombopora lepidodendrendes*, *Productus cora*** (of authors), ***Edmondia aspenwallensis*, *Nuculopsis ventricosa*, *Leda bellistriata***, and ***Astartella vera***. This horizon at the Eckelberry farm contains a number which are not found in either of the other localities. There are also six different types found here that are not reported for the type section at Portersville, in Perry County, about 15 miles southwest of Coal Hollow.

From this evidence we are bound to notice several salient facts. First, the faunas found in these three localities differ in several respects.

Second, the fauna found in Coal Hollow seems to be one containing brachiopods with an abundance of pelecypods and a sprinkling of other forms including one bryozoan. The fauna found at Norwich is one containing brachiopods, gastropods and cephalopods but no pelecypods. The Norwich collection also contains many specimens of the coral *Lophophyllum profundum* which may or may not be significant. The species found in the Eckleberry fauna appear to be more closely related to the forms found in Coal Hollow than to those found at Norwich. However, there are enough of the Norwich forms found to classify this fauna as one which is intermediate between Coal Hollow and Norwich. Evidently some of the Norwich forms reached this far south but did not get as far as Coal Hollow and vice versa. The number of species found in these three localities is far less than the number found in the type section at Portersville in Perry County. The faunas of these localities also seem to contain a much more predominantly brachiopod fauna than Condit reports for the type section. However, these variations might be due to differences in the living conditions in the different localities.

Third, the fauna varies so much from locality to locality, that it would be difficult to identify the number by means of its fossils alone.

In comparing the size of the species in this horizon with that of the same species in other horizons as reported in the literature, it is found that some of the forms are undersize while others are larger than usual. Three of the pelecypods found at Coal Hollow are undersize, two are normal, and one is larger than the dimensions commonly given for an average individual of that species. The forms which are abundant in both localities, *Chonetes verneuilanus* and *Derbya crassa*, are the normal size according to the dimensions given for these two species. Of the seven different forms found only at Norwich, four are of average size, one, *Lophophyllum profundum*, is larger than usual, and two are smaller than the dimensions given. One of these latter is *Ambocoelia planoconvexa*, which is by far the most abundant species at Norwich, is distinctly below normal in size.

THE URINARY ELIMINATION OF BORIC ACID

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In the use of "Metheneamine" ("Hexamethylenetetramine," "Urotropine") as a urinary antiseptic, some acid is customarily administered to maintain the acidity of the urine. Boric may be and is frequently used for this purpose. However, boric acid and borates are not without physiological effect when administered in sufficiently large amounts and if elimination does not proceed promptly, and accumulation takes place because of the slowness of elimination, toxic effects may result. Instances of harm arising from boric acid and borates are recorded in the literature (1). Schattenfroh states (2): "Undoubtedly the use of boric acid and borates is fraught with danger." Their use as preservatives in foods and food products is forbidden because of the belief that their presence in the foods that are consumed would be prejudicial to health.

Voicu (3) has shown that the toxicity of boric acid to organisms that produce ammonia from urea is lowered one-third by the presence of a two per cent glucose solution. The presence of glucose in the blood stream can conceivably decrease the toxicity of borates and boric acid in the body. The glucose may react with boric acid in the same manner as does the mannitol that is used in the titration method for its quantitative estimation.

With these facts in mind the authors have undertaken to study the rate of elimination of boric acid through the urinary tract.

METHODS

The titration method is the most convenient means for the quantitative determination of boric acid, and is sufficiently reliable for use when certain precautions are observed. These precautions consist in the main in the treatment of the boron containing sample with a mineral acid to a definite acidity, titration with a standard alkali solution to a known pH in the presence of an indicator, the addition of a weighed amount of mannitol and titration to a definite color change of the indicator after the addition of the mannitol. The alkali is usually standardized in terms of boric acid by check against samples of known boric acid content.

Biltz and Marcus (4) concluded that with phenolphthatein as the indicator phosphoric acid reacts as a dibasic acid and boric acid in the presence of mannitol as a monobasic acid.

Kolthoff (5) reported the determination of boric acid in the presence of phosphoric acid with phenolphthalein as the indicator. Mannitol was used in the estimation of boric acid. The end point for the titration is at a pH of 8.7.

Vastagh (6) claims no interference results in solutions which have been previously neutralized by potassium hydroxide with methyl red as the indicator when these methods are used except from the presence of silicic acid.

The reliability of the titration methods has been further tested by Foote (7) in his "Determination of Boron in Waters." He concludes that the titration method is the most convenient and reliable of all those studied.

TABLE I

TITRATION RESULTS OF KNOWN AMOUNTS OF BORIC ACID IN URINE
(100 c. c.)

Subject	Amount NaOH Used c. c. N/10	Amount H_3BO_3 Added mg.	Amount H_3BO_3 Found by Titration mg.	Amount H_3BO_3 Found, Per Cent of Total
A	38.78	266.7	239.9	89.9
B	39.43	271.5	243.9	89.8
C	36.98	254.3	228.8	89.8
D	39.50	271.5	244.4	90.0
E	36.15	268.5	223.7	83.3
F	38.00	270.1	235.0	87.0

EXPERIMENTAL

Twenty-four hour samples of urine were collected from six subjects. One hundred cubic centimeter volumes were run from the well-shaken 24 hour collections. No effort was made to control the diet of the subjects—they did not board at the same place—except that each subject ate approximately a uniform diet during the period of the study.

The 100 cc. urine sample was made distinctly acid to methyl red with hydrochloric acid, boiled gently for five minutes, to remove carbon dioxide, cooled and phenol red added. It was then adjusted to a pH of 7.6 by addition of carbon dioxide free sodium hydroxide and approximately 0.1 N hydrochloric acid if necessary. Three grams of mannitol were then added and the titration to a pH of 7.6 repeated. The amount of standard alkali needed for this adjustment in pH is a measure of the quantity of boric acid present. The equivalence of the standard alkali in boric acid was obtained by titration of known strengths of boric acid solutions.

Urine from each of the subjects without the addition of boric acid was titrated as blanks to test the procedure and to determine if it was free from borates. Negative results for borates were obtained in all cases.

Because of the color of the urine samples and the resultant difficulty of determining the end point, it was found necessary to decolorize the urine by means of absorbent charcoal. Tests proved that no measurable loss of boric acid resulted from such decolorization. When these facts were established samples of urine with the addition of known amounts of boric acid were titrated. The results for these tests are given in Table I.

TABLE II

ELIMINATION OF BORIC ACID THROUGH THE URINE

Subject	N/10 NaOH per 100 cc. Urine cc.	Volume Urine Voided cc.	Amount H_3BO_3 Found mg.	Corrected Amount H_3BO_3 mg.	Amount H_3BO_3 Adm. mg.	Amount H_3BO_3 Eliminated First Day. Per Cent of that Administered in Day Determined	Amount H_3BO_3 Eliminated in Two Days. Per Cent of Total Administered
1st day							
A	7.20	1627	724	805	975	82.56	..
B	7.97	913	728	810	975	83.08	..
C	7.65	760	360	400	975	41.99	..
D	6.64	1055	433	481	975	49.33	..
E	4.76	1182	348	418	975	42.87	..
F	7.09	1477	647	744	975	76.31	....
2nd Day						2nd Day	
A	10.25	1150	729	811	975	83.18	82.87
B	8.19	892	452	503	975	51.59	67.33
C	10.76	851	566	630	975	64.65	53.32
D	4.99	1673	516	573	975	58.87	54.10
E	7.98	1093	539	620	975	63.60	53.23
F	6.75	1652	689	792	975	81.23	78.77
3rd Day						3rd Day	Three Days
A	9.31	1715	986	1072	975	109.95	91.89
B	7.29	883	398	442	975	45.41	60.03
C	7.24	1492	668	744	975	76.32	60.65
D	4.55	1620	456	507	975	52.03	53.41
E	4.31	1744	465	527	975	54.06	53.51
F	6.57	1456	957	1100	975	112.82	90.12
4th Day							Four Days
A	3.83	877	208	231	000	....	100.00
B	3.88	1203	444	495	000	....	76.92
C	3.72	922	212	236	000	....	68.72
D	3.35	1090	226	251	000	....	61.95
E	1.22	1680	127	153	000	....	59.42
F	2.70	1819	300	349	000	....	102.05
5th Day							Five Days
A	1.10	1217	83	92	000	....	102.83
B	0.96	776	46	51	000	....	78.67
C	1.27	819	64	71	000	....	71.14
D	0.97	1051	63	70	000	....	64.34
E	1.10	1100	75	[illegible]	000	....	61.78
F	0.90	1200	66	[illegible]	000	....	104.65

The amount of boric acid actually determined is less than theory. During the course of the experiment, determinations were made on known addition amounts of boric acid to the samples with results that checked the results that are recorded in Table I for the different subjects under observation. The shortage in amounts determined must be due to the presence of particular buffers or the amounts of buffering materials in the different samples. Phosphates do not appear to be the cause of the difference in behavior as E was low in phosphates, while F was average and other investigators (4) (5) have already stated that phosphates do not interfere with the titration of borates. This individual peculiarity will be investigated further.

Corrections are applied in Table II in all determinations to correct for this divergence from theoretical results.

Blanks were run on a 24 hour sample of each subject before boric acid was administered. Then a total of 975 mg. of boric acid in three equal doses were administered daily at two-hour intervals after the three meals respectively, and 24 hours samples of urine collected (from 7:00 A. M. to 7:00 A. M.). One hundred cubic centimeter samples were taken from the well mixed 24 hour collection and titrated as already described for the blanks. The administration of boric acid was continued for three days and the collection of samples and determination of boric acid for six days, when no boric acid was found.

Tests for boric acid on the sixth and seventh days revealed only traces present that were of no quantitative significance.

The data in Table II indicate that the urinary elimination of boric acid is not uniform but varies with the individual and that one hundred per cent may be eliminated through the urine. This is not in harmony with the reported findings of Wiley (8) who states, that 80 per cent is eliminated through the urine and 3 per cent in the feces and perspiration.

SUMMARY AND CONCLUSIONS

1. Buffers in urine affect the quantitative determination of boric acid and corrections must be applied when the titration method is employed.
2. Quantitative elimination of boric acid through the medium of the urine varies in speed and completeness with the individual.
3. Two of the six cases investigated eliminated 100 per cent of the boric acid administered via the urine.
4. There is a considerable lag in the elimination.

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THE ANATOMY OF THE DIGESTIVE SYSTEM OF ONCOPELTUS FASCIATUS DALL.

(HETEROPTERA: LYGAEIDAE)

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INTRODUCTION

Oncopeltus fasciatus Dallas occurs over a wide range extending from Massachusetts westward over the greater part of the United States east of the Rocky Mountains and south and westward to Florida, Texas, California, Mexico and Brazil.

Its principal host plant is the common milkweed *Asclepias syriaca* L. but late in the summer the insect may be observed on willow foliage and the flowers of golden-rod and other Compositae.

This study was initiated in a course in entomology at the Ohio State University given by Dr. C. H. Kennedy on "The Morphology and Development of Insects." The interest developed in this course led to further pursuance of the work as a thesis problem.

The insects studied were collected from foliage of the common milkweed growing in Vigo County, Indiana.

The writer wishes to express his sincere appreciation for the helpful criticisms and assistance given by Dr. Kennedy and also for the worthy suggestions of fellow students.

METHODS

The collected material was killed and immediately placed in Kahle's fluid where it remained for two hours. After washing the material was stored in seventy per cent alcohol. For much of the gross anatomy study live material was dissected under a normal saline solution. Mayer's Hemalum and Fast Green FCF were employed in staining histological structures.

GROSS ANATOMY OF THE DIGESTIVE TRACT

GENERAL ANATOMY

Upon the basis of embryological origin the digestive tract is divided into three major portions. The stomodaeum or fore-gut arises as an ectodermal invagination at the cephalic region of the embryo. In like manner the proctodaeum or hind-gut arises at the caudal end. Since these two divisions of the tract are infolded portions of the body wall their own walls have the same essential structure as that of the body integument. The mesenteron or mid-gut is the connective portion of the tract between the stomodaeum and proctodaeum. Its epithelium is from embryonic endodermal tissue.

The three general divisions of the digestive tract are further differentiated into the following parts:

- I Stomodaeum
    - Pharynx
    - Oesophagus
    - Oesophageal valve
- II Mesenteron
    - First stomach
    - Second stomach
    - Third stomach
    - Fourth stomach
- III Proctodaeum
    - Pylorus (?)
    - Malpighian tubules
    - Rectum
    - Anus

In keeping with the phytophagous habits of the insect the entire digestive tract is of medium length being approximately one and one-half times the length of the body. It is relatively straight except in the regions of the second and third stomachs where it is coiled upon itself.

THE STOMODAEUM

The pharynx is a slightly enlarged portion of the stomodaeum just posterior to the mouth cavity and in the anterior half of the head cavity. It is a connecting portion between the mouth cavity and the oesophagus.

The oesophagus comprises the greater part of the stomodaeum and is approximately one-thirteenth the length of the whole tract. It is very narrow, tubular and extends dorsally from the pharynx along the median axis of the body. Its anterior half is enclosed by the head capsule while its posterior portion extends into the anterior part of the thoracic cavity joining the enlarged first stomach near the anterior edge of the scutellum. At the junction of the oesophagus and first stomach is located the oesophageal or stomodaeal valve.

THE MESENTERON

Just posterior to the oesophageal valve is the greatly enlarged first stomach. Its size and shape vary much depending upon the quantity of food material present within it but it usually extends well into the abdominal cavity along the median axis of the body. It is approximately one-third the length of the entire tract and is the region of the greatest diameter. Its walls at the anterior end usually lie in circular folds while it enlarges in pear-shaped fashion posteriorly into a smooth-walled structure. In the thoracic cavity it is completely enclosed by thick bunches of wing and leg muscles.

THE SALIVARY GLANDS

The salivary or labial glands lie dorsally and closely to the anterior end of the first stomach in the thoracic cavity and extend anteriorly covering the posterior portion of the oesophagus. They are paired, one gland lying on either side of a median line through the walls of the oesophagus and first stomach. Each gland consists of four parts. Two parts are each single pyriform lobes. One part is bi-lobed. The other part is a convoluted tube the distal end of which lies within the head cavity.

Each gland has a straight-walled duct through which the gland empties into the mouth. This duct arises at the junction of the lobes of the gland; it has an open lumen. This exit duct and its mate from the other gland join at the base of the beak into a very short common salivary duct which empties into the hypopharynx. This region of the salivary pump was not investigated closely.

Plate I, Fig. 1 illustrates the right salivary gland slightly pulled away from the wall of the first stomach to show the distinct parts. The left gland is turned ventral side up to show the junction of the salivary duct and the gland.

According to Snodgrass these glands are of ectodermal derivation arising in the embryo as paired invaginations just behind the bases of the rudiments of the second maxillary appendages. They are therefore treated here in connection with the stomodaeum.

At its posterior extremity the first stomach gradually narrows into a convoluted tube called the second stomach. The walls of the second stomach lie in folds the entire length of that organ and are of a pale yellow coloration in living specimens. The diameter of the second stomach is usually about 0.5 millimeters although this may fluctuate somewhat largely due to the amount of food material contained therein. It is slightly longer than the first stomach being a little less than one-third the length of the whole tract. The second stomach is usually coiled within the middle third of the abdominal cavity, however, it may be found in the posterior third in those cases in which the first stomach is unusually enlarged with food material.

Figure 1 illustrates the second and third stomachs pulled out of their normally coiled position.

The third stomach is scarcely distinguishable from the second stomach when the third stomach is void of food material except for the lack of folds in its walls. When filled with food, however, it is usually oval to spherical in shape and of a dark brownish coloration. It is from two and one-half to three millimeters in length. The third stomach narrows down into a short, narrow, smooth-walled tube called the fourth stomach.

The fourth stomach is about one millimeter in length and terminates the mesenteron posteriorly, unless the next enlargement of the canal into which the Malpighian tubules enter may be of endodermal origin.

THE PYLORUS (?)

Connecting the fourth stomach to the rectum is a slightly flattened, bulbular, smooth-walled enlargement of the tract questionably called the "pylorus." It is approximately one millimeter in length. Its diameter is nearly twice its length. Histological study gives evidence that this region may be either part of the mesenteron or perhaps part of the proctodaeum. This evidence will be discussed in connection with the histology of the digestive tract.

THE PROCTODAEUM

As mentioned in the preceding paragraph the "pylorus" may be considered as the most anterior portion of the proctodaeum.

The Malpighian tubules are long and narrow blind tubes extensively coiled throughout the posterior half of the abdominal cavity lying particularly near the dorsal body wall. Their distal ends lie freely in the body cavity and their proximal ends join the "pylorus." They are four in number two of which independently enter each of the lateral walls of the "pylorus." Figure 1 illustrates these tubules as being broken a short distance from their origin. The Malpighian tubules are generally considered to be of ectodermal derivation.

Lying along the median axis of the body, posterior to and connected with the "pylorus," is a thin-walled, pyriform structure called the rectum. Its anterior end is enlarged being about one millimeter in diameter and two millimeters in length. Its walls taper posteriorly into a narrow tube which terminates at the anus.

HISTOLOGY OF THE DIGESTIVE TRACT

THE STOMODAEUM

The stomodaeum anterior to the posterior edge of the head capsule was not studied histologically.

The histological structure of the oesophagus is quite uniform except at its posterior end in the region of the oesophageal valve. A section through the oesophageal walls (Plate II, Fig. 2) discloses the following structures from within outward: (1) intima, (2) epithelial cells, (3) circular muscles and (4) longitudinal muscles.

An inner lining of non-cellular cuticula or intima lies apart from the epithelial cells and separates them from the lumen. The epithelial cell layer is very irregular in shape. It appears mostly as a homogeneous mass except for the scattered nuclei within it. No cell walls are noticeable. Both circular and longitudinal muscles are scattered and are from two to three strands in thickness.

At the junction of the oesophagus and first stomach is the oesophageal valve (Plate II, Fig. 4). The epithelial cells of the oseophagus are elongated forming a fold which extends partially into the lumen of the first stomach. There is a heavy grouping of circular muscles proximal to the basement membrane of the epithelial cells constituting the fold. It is particularly noted that there is no reversal in the relative position of the muscle layers at the oesophageal valve. The intima which lines the oesphagus ends abruptly just posterior to the fold of cells which make up the valve indicating the posterior termination of the stomodaeum.

THE MESENTERON

Histologically the structure of the mesenteron is much the same throughout. It consists of a layer of epithelial cells resting upon a basement membrane, a layer of internal circular muscles and a layer of external longitudinal muscles. No peritrophic membrane is present which is considered quite typical of sap feeding insects. Likewise an intima is lacking. The epithelial cells throughout the mesenteron, unlike those in the oesophagus, are much larger and show distinct cell walls. A thinness of the muscular layers is characteristic of the mesenteron.

The wall of the first stomach is relatively thin in comparison with the diameter of the stomach. The epithelial cells are short but vary somewhat in shape from nearly cuboidal to oblong. Plate III, Figure 6 illustrates the cellular appearance of the first stomach when it is void of food material. The layer of circular muscles is particularly thin and consists of a single strand. The longitudinal muscles are few and very scattered.

In the second stomach (Plate III, Fig. 8) the epithelial cells are longer and more uniform in length. The circular muscle layer consists of one strand and a partial second strand. The longitudinal muscles, as in the first stomach, are few and scattered.

The histological structure of the third and fourth stomachs (Plate III, Figures 9 and 7) is particularly similar. The epithelial cells vary greatly in size, some cells being six times larger than other cells, thus making the epithelium very irregular in thickness. Activity of the digestive epithelium is noted particularly in the third stomach. Some of the distended epithelial cells in the third stomach are seen undergoing a degeneration process. Also, a regenerative cell is shown. In the degeneration process, according to Snodgrass, the mesal border of the degenerating cell swells out in the form of a bud, which becomes constricted at its base and finally separates as a free sphere from the body of the cell as illustrated on Plate III, Figure 9. These disintegrated cells are replaced with new cells formed from the regenerative cells. In the fourth stomach some of the epithelial cells show striated borders. The muscularis in the third and fourth stomachs is heavier than in any other portion of the mesenteron. A layer of two strands of circular muscles is present. No longitudinal muscles were detected in the third stomach. A few scattered longitudinals are noticeable in the fourth stomach.

THE PYLORUS (?)

This enlargement of the digestive tract, into which the Malpighian tubules empty, is made up of long, very thin epithelial cells resting upon a basement membrane. Lying closely to and outside of the basement membrane is a layer of rather heavy, plainly striated, longitudinal muscles from one to two strands in thickness. No circular muscles were detected. No pyloric valve was found. Because only longitudinal muscles are present there is no reversal of the muscular layers in the "pyloric" region.

The point of attachment of the Malpighian tubules commonly marks the anterior extremity of the proctodaeum. Embryologists also generally agree that these tubes take their origin as outgrowths of the proctodaeum. The fact that the Malpighian tubules enter the "pylorus" would indicate that this region is part of the proctodaeum. The proctodaeum, however, is characterized by having an intima. Contrary to this, the so-called "pylorus" has no cuticular lining. This condition, then, would indicate that the "pylorus" is a continuation of the mesenteron.

Snodgrass defines the pylorus as "an anterior part of the proctodaeum usually containing the pyloric valve, sometimes distinctly differentiated from the true intestinal region and forming anatomically the rear end of the stomach."

Our evidence, then, is not decisive as to whether the lining epithelium is derived from endoderm or from proctodaeal ectoderm.

THE PROCTODAEUM

The Malpighian tubules join directly into the walls of the "pylorus." The structure of these tubes is relatively simple. The lumen of the tube in cross section is enclosed by three or four large, thin-walled cells which contain very large and distinct nuclei. No muscularis could be detected.

The structure of the rectum is quite similar to that of the oesophagus. From its lumen outward it is made up of the following structures: (1) intima, (2) epithelial cells, (3) internal circular muscles and (4) external longitudinal muscles. The intima which separates the epithelium from the lumen lies more closely associated with the epithelial cells than it did in the oesophagus. The epithelial cells are similar to those in the oesophagus in that they show scattered nuclei and no cell walls. They are also very irregular in shape. The circular muscle layer consists of a single strand of muscles. The longitudinal muscles are rather heavy. They occur in scattered patches of from one to two strands in thickness.

Investigation of an anal sphincter could not be carried on satisfactorily due to the chitinized walls about the anal opening.

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EXPLANATION OF PLATES

Plate I

Fig. 1. Gross dissection; alimentary tract removed in part from the body cavity. Left salivary gland turned ventral side up. Malpighian tubules cut off near their point of origin.

Plate II

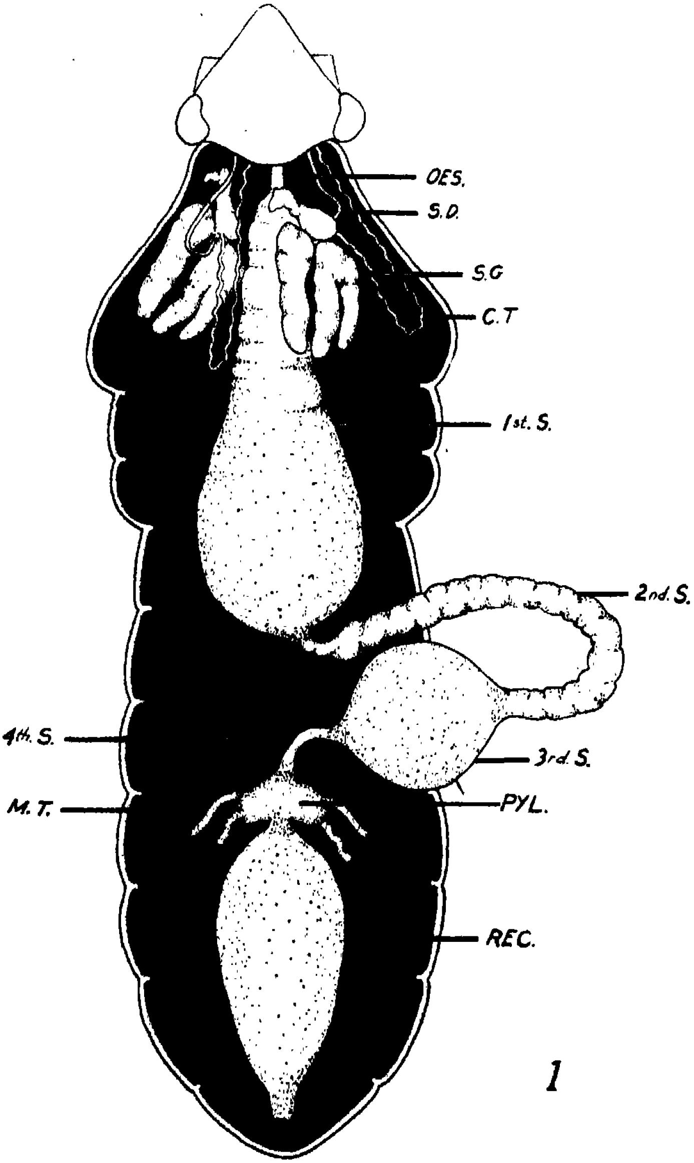
Fig. 2. Cross-section through the oesophagus.
Fig. 3. Longitudinal section through the "pylorus."
Fig. 4. Longitudinal section through a portion of the oesophagus, the oesophageal valve and part of the first stomach.
Fig. 5. Cross-section through a Malpighian tubule.

Plate III

Fig. 6. Cross-section through the first stomach.
Fig. 7. Cross-section through the fourth stomach.
Fig. 8. Cross-section through the second stomach.
Fig. 9. Cross-section through the third stomach.

KEY TO ABBREVIATIONS

C.M.—Circular muscle.
C.T.—Convoluted tube.
EPI.—Epithelial cell.
INT.—Intima,
L.M.—Longitudinal muscle.
LU.—Lumen.
M.T.—Malpighian tubule.
OES.—Oesophagus.
O.V.—Oesophageal valve.
PYL. (?)—"Pylorus."
REC.—Rectum.
R.C.—Regenerative cell.
1st. S.—First stomach.
2nd. S.—Second stomach.
3rd. S.—Third stomach.
4th. S.—Fourth stomach.
S.B.—Striated border.
S.C.—Secreting cell.
S.D.—Salivary duct.
S.G.—Salivary gland.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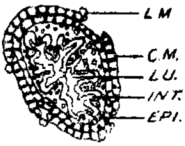
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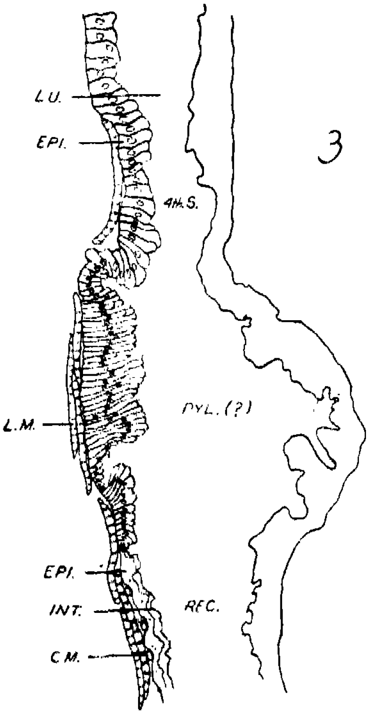
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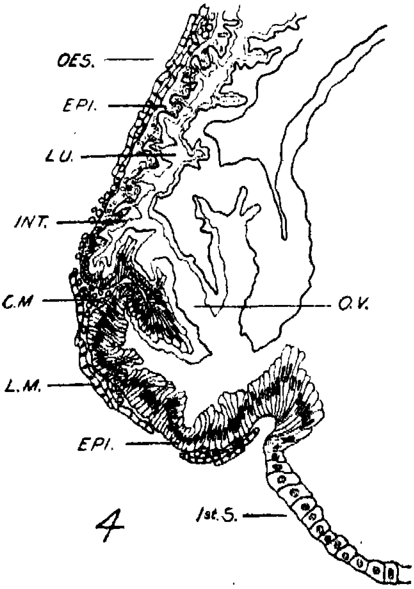
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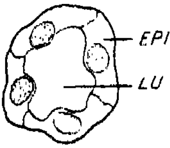
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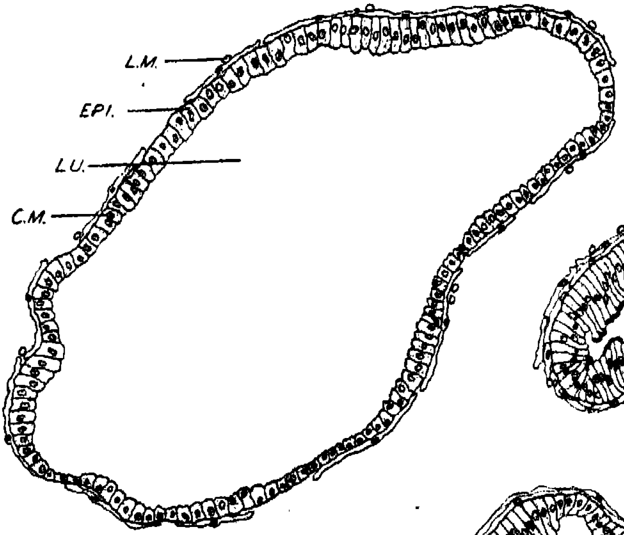

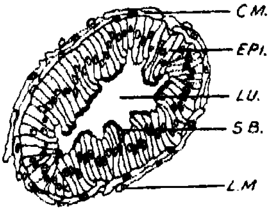

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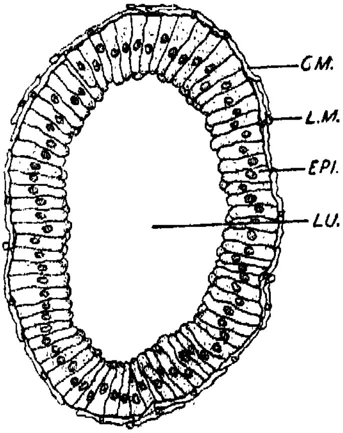

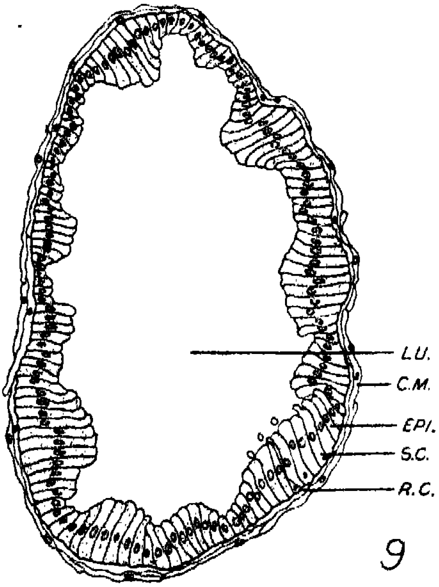

9

SOME NEW SPECIES OF IDIOCERUS (HOMOPTERA-CICADELLIDAE)

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Idiocerus borealis n. sp.

Resembling *pallidus* in form and appearance but with simple antennae and smaller in size. Length 5.5–6 mm.

Vertex almost parallel margined, male antennae without discs or black coloration.

Color pale yellow without dark markings, black markings of abdominal segments visible through elytra.

Genitalia: Female segment rather strongly produced to form a blunt median tooth. Male plates rather broad.

Described from one female specimen from Amery, Wisconsin, and two male specimens from Pembine, Wisconsin and Cameron, Wisconsin, respectively collected during July and August, 1916. Holotype male (Pembine, Wisconsin) allotype female and male paratype in senior author's collection.

Idiocerus levis n. sp.

Resembling *pallidus* in form and appearance but with slight discal enlargements on antennae. Length 5.5–6.5 mm.

Male antennal discs only slightly larger than antennae and elongate.

Color pale yellow, elytra appearing milky white.

Genitalia: Female segment rather strongly roundedly produced at middle. Male plates rather long and narrow.

Described from a pair of specimens collected at Meddybemps, Maine, July 13, 1922, by R. J. Sim. Holotype male and allotype female in senior author's collection.

Idiocerus solus n. sp.

Resembling *nervatus* but with faint markings and without discs on antennae. Length 4.5–5 mm.

Vertex shorter at middle than next eyes, broadly curved. Antennae of male simple, without discs.

Color green tinged with yellow. Face vertex and pronotum unmarked. Scutellum with faint markings in basal angles. Elytra subhyaline, veins pale, inconspicuous.

Genitalia: Female segment almost truncate, slightly produced at middle. Male plates rather short and broad.

Described from a pair of specimens collected at Greensburg, Pennsylvania, August 21, 1901, and a pair collected at Clarksville, Tennessee, July 3, 1915. Holotype male, allotype female (Greensburg, Pa.) and male and female paratypes in collection of senior author.

Idiocerus pyramidatus n. sp.

Resembling *nervatus* but larger, darker green without dark markings. Length 5–5.5 mm.

Vertex shorter at middle than next the eyes. Antennal discs of male rather large, black, elongate oval, apex tapered.

Color green, basal angles of scutellum yellow, elytra subhyaline. Nervures pale, indistinct.

Genitalia: Female segment short, roundedly produced, forming a broad blunt tooth at middle. Male plates narrow.

Described from three male and three female specimens collected at Prescott, Huachuca Mts. and Chiricahua Mts., Arizona and Davis Mts., Texas, during June and July, 1935, by Prof. J. N. Knull. Holotype male (Huachuca Mts., Ariz.), allotype female (Chiricahua Mts.), and male and female paratypes in collection of senior author.

Idiocerus stellaris n. sp.

Resembling *suturalis* but distinctly marked and with elongated male antennal discs. Length 6–7 mm.

Male antennal discs elongate oval, pointed at both ends.

Color yellow, face and vertex unmarked. Pronotum brown except for anterior margin and curved spot along margin behind each eye. Scutellum yellow, basal angles brown elytra uniform smoky brown except for anterior costal margin, veins dark. Beneath yellow.

Genitalia: Female last ventral segment roundedly produced. Male plates long and narrow.

Described from one female and nine male specimens from Northeast, Pennsylvania, July 4 to 12, 1928; Greenfield, Pennsylvania, July 20, 1920; Cranberry Lake, New York, July, 1917, and July and August, 1924; and Tobyhanna, Pennsylvania, August 14, 1920 (J. G. Sanders). Holotype male (Cranberry Lake, N. Y.) allotype female (Tobyhanna, Pa.) and male paratypes in the senior author's collection.

Idiocerus verticis (Say)

Jassus verticis Say Jour. Acad. Nat. Sci. Phila., 6 : 308 (1831); Compl. Writ., II, 383.

The name *verticis* has been applied for many years to a small insect with two round black spots on the vertex. According to the original description the vertex, pronotum, and scutellum are irrorate but without black spots on the vertex. As a consequence a neotype male which agrees with the original description is erected at this time, collected at Covington, Tennessee, June 18, 1915, by the senior author and in his collection. The type locality was cited as Missouri by Say.

Idiocerus rotundens n. sp.

Resembling *verticis* in size and appearance but paler with two small round black spots on vertex. Length 4.5–5 mm.

Vertex shorter at middle than next the eyes, antennae with large, circular terminal black discs.

Color pale yellow, ocelli black, face with a broad longitudinal orange stripe. Clypeus, sutures of face and lorae orange. Vertex with a round, median dusky area and a round black spot either side. Pronotum pale, dark spots of scutellum visible. Scutellum pale, marked only by the black spots at base. Elytra white, veins to apical cross veins white, beyond apical cross veins, brownish. Abdomen and beneath pale, yellowish, without dark markings.

Genitalia: Female last ventral segment truncate. Male plates long and slender.

Described from a female and two male specimens collected at Beloit, Wisconsin, July 11, 1936, and a male from Milwaukee, Wisconsin, July 18, 1916, all collected by the senior author. Holotype male (Milwaukee, Wis.), allotype female, and male paratypes in senior author's collection.

Idiocerus tenuens n. sp.

Resembling *verticis* in size and general appearance, but darker and with apical portions of antennae enlarged. Length 5 mm.

Vertex almost parallel margined. Male antennae with apical third slightly widened and black forming an elongate, narrow disc widened toward apex and narrowed basally.

Color yellow, face with a slightly darker median stripe. Pronotum with a spot either side of, and anterior to middle. Basal angles of scutellum with black triangular spots which are visible through pronotum. Elytra subhyaline with dark veins.

Genitalia: Male plates narrow.

Described from a single male specimen collected at Austin, Nevada, August 3, 1936, by J. N. Knull. Holotype male in senior author's collection.

Idiocerus nigrens n. sp.

Resembling *musteus* in form and color but more darkly marked and with small round antennal discs. Length 4.5 mm.

Male antennae with small oval terminal discs.

Color, yellow, vertex with a pair of medium sized round black spots and an oblique mark behind each next the eyes. Pronotum black, humeral angles narrowly white margined. Scutellum black, a pale spot on margin midway on either side and a small spot at apex white. Elytra milky white, basal third of inner clavus and apical third black. Apex of elytra smoky. This gives the appearance of a dorsal black stripe interrupted twice. Male plates short and very narrow.

Described from a single male specimen from Newport, Washington, August 8, 1926, collected by R. W. Haegele.

Holotype male in collection of senior author.

Idiocerus cinctus n. sp.

Resembling *formosus* but smaller, paler in color with two conspicuous transverse bands and with simple antennae in the male. Length 5 mm.

Vertex almost transverse, longer next the eyes than length at middle. Male antennae simple, without discs.

Color yellow, face and vertex unmarked. Pronotum milky white, anterior half mottled with brown. Scutellum with basal angles and a pair of large round spots on the disc, brown. Elytra milky white, transparent. A broad transverse band across apical third of clavus, the apex of elytra to base of apical cells and the anterior costal area, dark brown. Anterior half of outer claval vein brown, apical half white.

Genitalia: Male plates rather broad and long.

Described from two male specimens collected at Idaho City, Idaho, July 13, 1930 (DeLong), and one male from La Grande, Oregon, collected by Dr. H. H. Ross, July 30, 1936. Male holotype and male paratype in senior author's collection. Male paratype in Illinois Natural History Survey collection.

Idiocerus chisosus n. sp.

Resembling *dolosus* in general appearance but paler in color. Length 4.5–5 mm.

Vertex almost transverse and parallel margined. Male antennae with small elongate oval discs.

Color pale brown, face unmarked, a pair of large round black spots on vertex. Pronotum with a row of irregular black spots on anterior margin either side of middle. A pair of black triangular basal spots and a pair of small round spots on the disc of scutellum. Elytra smoky brown, veins white.

Genitalia: Female segment roundedly produced, shallowly notched at middle. Male plates narrow.

Described from a series of eight female and fourteen males collected at Davis Mts. and Chisos Mts., Texas, and Chiricahua Mts., Arizona, during July, 1936, by J. N. Knull. Holotype male (Davis Mts., Arizona) allotype female and male and female paratypes in the senior author's collection.

Idiocerus caliginosus n. sp.

Resembling *dolsus* in form and general appearance but smaller and with darker markings. Length 5 mm.

Vertex transverse, shorter at middle than next either eye.

Color white marked with black and brown. Face heavily mottled with black. Sutures of front and clypeus with faint black marginal lines. Vertex with the two round black spots fused with angular spots which extend to upper margins of eyes. A pair of proximal spots between them. Pronotum heavily mottled on each side of pronotum excepting a broad longitudinal milky white stripe in the middle. Scutellum with basal angles, a pair of proximal spots at base, a pair of triangular spots on disc and a pair of triangular spots at apex black. Elytra smoky, veins broadly white interrupted with black on clavus and disc of corium. Outer veins white, apical veins brown.

Genitalia: Female last ventral segment strongly roundedly produced, slightly notched at center.

Described from two female specimens collected in the Chisos Mts., Texas, July 9, 1936, by J. N. Knull. Holotype female and paratype female in senior author's collection.

SOME EFFECTS OF TEMPERATURE ON THE DEVELOPMENT AND OVIPOSITION OF MICROBRACON HEBETOR (SAY)

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The present paper summarizes some preliminary observations on the life history of *Microbracon hebetor* (Braconidae) as a parasite of the Mediterranean flour moth, *Ephestia kühniella* Zeller, under controlled temperature and humidity conditions. This work was done at the Ohio State University in 1931 and the writer is deeply indebted to Professors Alvah Peterson and William M. Barrows for advisory assistance during the progress of the study.

METHODS

The cages used for rearing *M. hebetor* were 18 x 50 mm. shell vials which were closed with screen caps. A fresh, moist, seedless raisin, mounted on an insect pin, was kept in each container as a possible source of moisture and food as a supplement to the normal feeding from punctures made in the host larvae.

Temperature variations were held within about one degree Centigrade on either side of the desired temperature and relative humidity was maintained near 73.0 per cent by means of saturated solutions of sodium chloride.

Examinations of the insects were made daily at about the same hour and two well developed larvae of *E. kühniella* were supplied as hosts to each female parasite. The females were confined singly in cages and were transferred daily to clean vials by means of a suction tube. Fertile females which were reared at 26° and 28° C. were used in the oviposition studies. Males were excluded during the tests to avoid disturbing the oviposition reactions. The eggs, which are deposited externally on the host larvae, were counted by rotating the vial under a binocular microscope.

RESULTS

Pre-imaginal development. The duration of the developmental stadia with standard errors is shown in Table I and is illustrated by Figure 1. The time required by individual insects varied from 8 days at 32° to 39 days at 16° C. The egg and larval stages combined required less than one-half of the time spent within the cocoon or about thirty per cent of the time required from deposition of the eggs to the emergence of the adults. Determinations were made of the duration of the egg and larval periods in combination since the brevity of the stadia made it difficult to determine the values separately.

Between 20° and 32°, the rate of development appears to have a linear correlation with temperature although the regression line may be slightly curvilinear (Fig. 1). These results are, therefore, not strictly in accordance with those of Payne (1934) who states that the curve is probably exponential. However, the present study indicates that the curve may be more definitely exponential below 20° since a marked deviation occurs at 16° and a few specimens were reared at 12° which is below the minimum effective temperature shown by the linear relationship. The rate of development used in Table I and Figure 1 is an index which is equal to 100/time, or the per cent of total development which would take place in one day at the mean rate for the entire period. The regression line (Fig. 1) was calculated by the least squares method.

TABLE I

Development of *M. hebetor* at Different Constant Temperatures
(Duration of the Developmental Stadia in Days)

Temperature °C.	Egg and Larval Period	Number Reared	Pupal Period	Number Reared	Total Pre-imaginal Period	Number Reared	Index Rate of Development	Thermal Increment (above 12.7) in Day-Degrees
32	2.40	27	5.72	28	8.12 ± .06	28	12.31	156.72
30	2.62	175	6.21	279	8.83 ± .04	279	11.32	152.76
28	3.03	245	6.86	149	9.89 ± .06	149	10.11	151.32
26	3.48	160	8.07	233	11.55 ± .06	233	8.66	153.62
24	4.11	96	9.76	164	13.87 ± .10	164	7.21	156.73
20	6.86	123	14.35	97	21.21 ± .12	97	4.71	154.83
16	10.73	110	21.98	41	32.71 ± .28	41	3.06	107.94

As is shown in the last column of Table I, the thermal increment necessary for the development of *M. hebetor* approaches a constant value for the temperature range between 20° and 32°. Effective temperatures, as are shown in Table I (last column) are those above 12.7° as indicated by the calculated regression line (Fig. 1) and the value of the thermal constant is 154 day-degrees.

As has been recorded previously, (Whiting 1921 and Schlöttke 1926) the coloration of the adults varied progressively from light to dark as the temperature at which they were reared graded downward.

Oviposition. An indication of the fecundity of *M. hebetor* is afforded by a maximum deposition of 312 eggs by one individual while the mode for 53 individuals which were reared at 26° and 28° C. falls between 100 and 200 eggs.

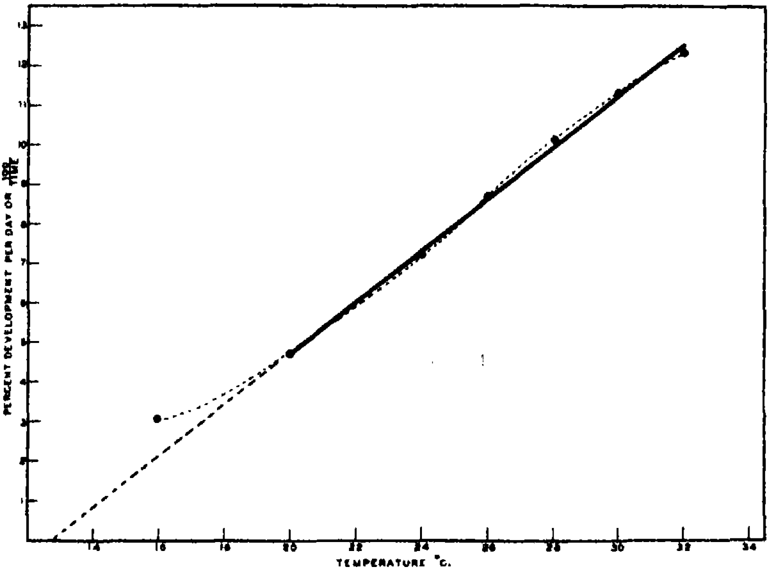

FIG. 1. Graph showing rates of development at different constant temperatures.

The minimum temperature at which eggs were regularly deposited was 14° C. With few exceptions, egg deposition ceased abruptly when laying individuals were transferred to a cabinet which was controlled at 12° C. The maximum temperature at which eggs were regularly obtained was 36° C. Egg-laying was suspended at 38° C. except in the case of exceptional individuals which deposited several eggs under these conditions. The optimum temperature is near 26° C. since the rate of egg-laying is near a maximum at this temperature and the total number of eggs deposited is greater than at higher temperatures where the oviposition period is shorter. The pre-oviposition period is very short since eggs were usually obtained on the first or second day following emergence. A post-oviposition period was not very evident since only a few individuals showed a definite lapse in egg-laying before death occurred. Fertility apparently does not have a marked effect on egg-laying since virgin females exhibit a strong and uniform oviposition behavior. The eggs of virgin females develop but always produce males.

An influence of temperature on the oviposition rate and fecundity of insects has been observed by a number of authors. Hunter and Pierce (1912) observed that the oviposition rate of the cotton boll weevil, *Anthonomus grandis* Boh., was strongly affected by temperature. No data are given but the influence of temperature is illustrated by a curvilinear regression line. Studies of the effect of temperature on the fecundity of *Trichogramma evanescens* Westwood, show that the oviposition rate of this species is largely a function of temperature. (Schulze 1926). The correlation shown by these data was regarded as curvilinear by Janisch (1930), who fitted the data with an exponential regression curve. The effect of a temperature gradient on the rate of egg-laying of the queen bee is very definitely curvilinear as is shown by Dunham's data (1931). The rate of reproduction of the grain aphis, *Toxoptera graminum* Rondani, is also apparently a curvilinear function of temperature (Wadley (1930) and data of Isely (1932) on the cotton boll weevil suggest a similar relationship.

TABLE II

Rates of Egg-Laying of *M. hebetor* at Different Constant Temperatures

Temperature -C.	Number of Females	Oviposition Rate (Eggs per Day per Female)	Temperature Coefficients (μ)
38	5	0.00	
36	7	12.59	
28	21	14.70	
26	10	14.57	24,200
24	22	11.10	18,000
22	18	9.03	23,900
20	22	6.85	19,200
18	8	5.47	20,400
16	17	4.29	
14	5	1.80	
12	7	0.00	

Data on the rate of egg-laying of *M. hebetor* at various constant temperatures are shown in Table II and are illustrated by

Figure 2. These results also show that the effect of temperature on the oviposition rate is not directly proportional to temperature through an appreciable range. The effect of the temperature gradient appears to define a sigmoid curve between 16° and 28° C. which indicates that the oviposition rate may be better interpreted as an exponential than as a linear function of temperature.

The master reaction theory that the velocities of such processes are controlled by the speed of a single chemical reaction has been quite generally considered by physiologists and temperature characteristics (μ of the Arrhenius equation) have been

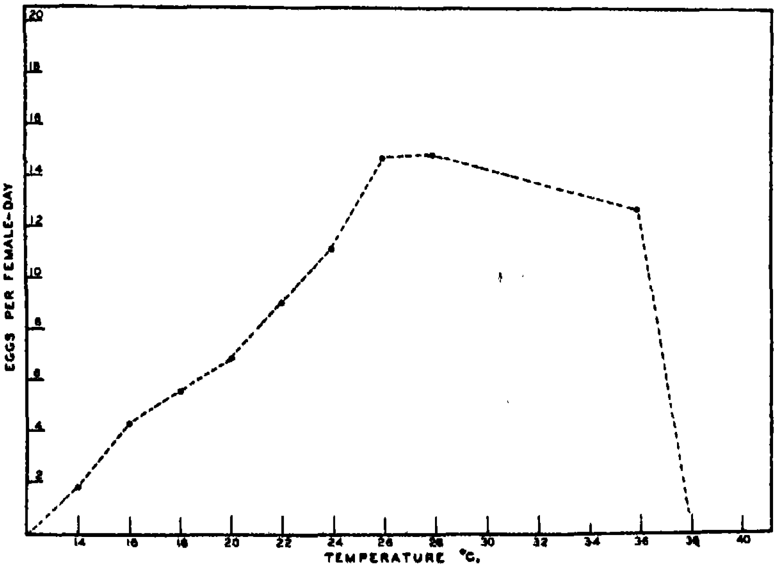

FIG. 2. Graph showing oviposition rates at different constant temperatures.

calculated for a great variety of biological activities. Objections to the use of the Arrhenius formula in biology have been made by Fulmer and Buchanan (1929) and by Belehrádek (1928–30) who advances the theory that the speed of such reactions is dependent upon the viscosity of protoplasm or the "rate of diffusion in viscous media."

Consideration of different regression equations has demonstrated the difficulty of finding the best hypothesis by the method of curve fitting. Variability in the oviposition response as well as the fact that the curve extends only through a narrow temperature range make it evident that a slight difference in agreement in favor of one equation is not significant. However, it is shown in Table II that the oviposition rates are not obviously discordant with the master reaction theory since the value of the temperature characteristic does not vary regularly in any order which would indicate that it is not a constant for the process between 16° and 26° C. The data depart widely from the calculated regression curve at higher temperatures and also at 14° and below the minimum temperature for oviposition since the curve does not reach a zero.

These results indicate that the effect of temperature on the oviposition rate does not permit the simple analysis which is provided by the thermal constant theory for the development of this species since a definite thermal increment does not have a constant effect through any range of temperature. In the case of such relationships, factorial treatment of thermal increments between narrow temperature limits would provide a closer index to the influence of temperature on insect oviposition than would the method of direct temperature summation by day-degrees.

SUMMARY

The approximate duration of the developmental stages of *M. hebetor* has been determined at constant temperatures for the range of 16° to 32° C. The egg and nymphal periods combined require about one-third and the pupal period about two-thirds of the total pre-imaginal period. The data on development conform well to the thermal constant theory between 20° and 32° C. Mean oviposition rates do not indicate a thermal constant but show a sigmoid relationship which shows only a slight difference in the rate of egg-laying between 28° and 32° C. The thermal constant for development has a value of 154 day-degrees and the temperature characteristic for oviposition between 16° and 26° C. has a least squares value of 21,400.

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THE EMBRYO SAC OF ERAGROSTIS CILIANENSIS (ALL.) LINK

A NEW TYPE EMBRYO SAC AND A SUMMARY OF GRASS EMBRYO SAC INVESTIGATIONS

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The embryo sacs of the grasses have been examined by about twenty-five investigators. Of the sixty grasses studied only twenty-three species have fairly complete data recorded concerning the development of the embryo sac, and forty-seven species have the type of embryo sac recorded. The number and position of the antipodals, which vary from three to sixty (Bambusa, in tables), have attracted more attention than any other phase of the embryo sac studies, for the antipodals have been studied in fifty-five species. Information about the group as a whole is scattered and incomplete, as will be seen in the accompanying tables, and there is variation in the records.

Eragrostis cilianensis (All.) Link, is the name preferred in Hitchcock (18) for the grass known to many as *Eragrostis major* Host. The spikelets were prepared by killing and fixing in hot crom-acetic or hot F. A. A. and kept in 50% Hydroflouric acid from five to ten days before embedding.

THE SPIKELETS AND OVULES

The spikelets of this grass have from ten to forty flowers with the basal flowers maturing first. Longitudinal sections of the whole spikelet show the flowers in various stages of maturity from the base to the tip. The young ovule develops at right angles to the carpel wall (Fig. 1) and gradually grows so that its longitudinal axis is finally parallel with that of the carpel (Fig. 10). The inner integument develops faster than the outer, which never completely covers the ovule and finally disappears (Figs. 12 and 13).

THE ARCHESPORIAL CELL AND MEGASPORES

There is one archesporial cell and no tapetal cell. Four megaspores are formed and are arranged in the T-form (Figs. 2, 3, 4, 5). The young ovules of Eragrostis are so small that 4-micron sections had to be cut to be certain of the T-form tertad. Schnarf (1926, *Bambusa*, *Coleanthus*) and Horton and Beck (1932), *Bromus marginatus*) show T-form tetrads; and Miller (1920, *Zea*) reports no walls between the megaspores and says that all four function ("lily type"). Weatherwax reports a linear tetrad in Zea, as is the case in all other species reported.

The inner megaspore (Figs. 3, 4, 5) of Eragrostis always grows into the embryo sac and its nucleus does not divide until after the disintegration of the other three megaspores (Fig. 5). This is the case in all other grasses that have been studied except that Anderson (1927) reports that in *Poa* the outer megaspore develops occasionally and that there are sometimes two rows of megaspores from two archesporial cells.

THE EMBRYO SAC

The embryo sac develops as the normal type through the two- and four-nucleate stages (Figs. 6, 7). With the formation of the eight-nucleate stage the four chalazal nuclei are immediately separated from the rest of the embryo sac as four antipodal cells (Figs. 8, 9, 10); one or two of these divide immediately so that there are commonly five or six antipodal cells (Fig. 11) at fertilization time. The number of antipodals in grass tribes varies from three to sixty, as shown in the tables.

The four nuclei at the micropylar end of the sac function, as the egg, one synergid, and two endosperm nuclei (polar nuclei) (Figs. 10, 11). This organization of an embryo sac is a new type not only for the grasses but for all plants. The number of antipodals in *Eragrostis* is always four or more and they are immediately separated from the rest of the sac as antipodal cells. Consequently no chalazal nucleus takes part in the formation of the endosperm. Only one synergid is ever formed, and the egg and the one synergid are separated from the remaining two nuclei as cells (Figs. 10, 11). These remaining two nuclei fuse in the formation of the endosperm nucleus (Figs. 10, 11). The pollen tube enters through the micropyle and fertilization occurs as usually described.

The embryo sacs of forty-two grasses have been reported as normal-T sacs. Three cases have been found to have the Scilla-T (*Coleanthus*, Schnarf, 1926; *Melica nutans* and *M. altissima*, Fischer, 1880). Miller (1920) found that in *Zea* all four megaspores function in the formation of the eight-nucleate sac as in the so-called "lily type" embryo sac, and Weatherwax (1919) found the normal-T in *Zea*.

DEVELOPMENT OF SEED COATS

The embryo sac elongates and the chalazal end absorbs its way into the nucellus, while the antipodals remain *in situ* and so become lateral to the embryo sac (Figs. 11, 12). Most of the nucellus is absorbed by the developing endosperm until practically only the outer layer remains (Fig. 12), and even that is at last partly destroyed (Fig. 14). The inner integument completely surrounds the ovule and the outer integument disappears; so that the seed coat is made up of the inner integument and one layer of the cells of the body of the ovule except on the side of attachment to the carpel (Figs. 14, 16). With but one exception in all species examined in the grasses the outer integument disappears and the inner integument becomes the seed coat (Figs. 14, 24, 36, et al). Anderson states that in *Poa* the outer integument does not entirely disappear but the cells are much crushed.

THE ENDOSPERM

The endosperm is free-nuclear, and by the time the fertilized egg has divided there are from 25 to 35 nuclei lying in the periphery of the cytoplasm. Cell walls are formed first against the walls of the seed coat and develop toward the center until the endosperm tissue fills the whole body of the ovule. All grasses that have been studied have a free-nuclear endosperm of the same type.

THE EMBRYO

The fertilized egg elongates and divides into a short four-celled embryo. The cell at the micropylar end sometimes does not divide immediately, but eventually it produces a several-celled suspensor (Figs. 15, 16, 17) that later is almost completely absorbed (Fig. 19). The upper cells of the young embryo soon form a bulbous tip, and the epidermis becomes distinct (Figs. 14, 15). The development of the scutellum is the next evidence of growth (Fig. 16). It is formed by the continued growth of that part of the bulbous embryo, the tip becoming the top of the scutellum and the cells above the suspensor forming the base of the scutellum. The stem tip and the coleoptile develop from the lower half of the outer side of the bulbous portion (Figs. 16, 17) opposite the base of the young scutellum. The scutellum develops rapidly and the basal portion pushes the lower end of the embryo away f om the endosperm (Figs. 18, 19).

The parts of the grass embryo have been much discussed. The opposing views are well presented in the papers of Avery (3) and Boyd (5).

SUMMARY OF ERAGROSTIS EMBRYO SAC DEVELOPMENT

1. There is no tapetal cell.
2. There is a T-form tetrad of megaspores.
3. The inner megaspore develops into the embryo sac.
4. The two- and four-nucleate stages occur as in the Normal-T embryo sac.
5. All four nuclei at the antipodal end of the sac are separated from the rest of the sac as antipodal cells.
6. Two of the nuclei in the micropylar end of the sac fuse in the formation of the endosperm nucleus.
7. The remaining two nuclei in the micropylar end of the sac become the egg and a synergid.
8. The pollen tube enters the sac through the micropyle and fertilization and triple fusion occur.
9. The endosperm is free-nuclear.
10. The seed coats are formed from the outer cell layer of the ovule and the inner integument.
11. The embryo develops as the ordinary grass embryo type.

SUMMARY OF THE GRASS EMBRYO SAC INVESTIGATIONS

1. The antipodals, embryo sacs, *et altera* are summarized in the accompanying tables showing lists of grasses studied and findings in each.
2. Archesporial Cells. Two archesporial cells have been reported in the grass ovules by Fischer (1893), Koernicke (1896), Tannert (1905), Kuwada (1920), Coulon (1923), Schnarf (1926), Anderson (1927).
3. Polyembryony. This condition in the grasses has been seen in *Oryza* by Jones (1928), Kuwada (1910), Komuro (1922); in *Zea* by Brown (1860); in *Poa* by Nishimura (1922) and Anderson (1927); in *Triticum* by Eichinger (1910); in *Eleusine coracana* by Rangaswami (1930). More than one embryo is occasionally found in *Zea* by those testing corn in germinators.
4. Parthenogenesis. This phenomenon was first observed in grasses by Coulon (1927) in *Nardus Stricta*. He found that the pollen was sterile. Gaines and Aase (1926) in *Triticum* and in *Secale*, and Stenar (1935) in *Calamagrostis* have found parthenogenesis.
5. Caryopsis. The fruits of grasses are all the typical caryopsis, and the inner integument forms the seed coat, except that in *Poa* the outer integument is also a part of the seed coat. Stopf (1904) in *Melocanna bambusiodes* of the Bambuseae found that the ovules were "naked, endospermless and viviparous." The embryos drop out of the fleshy fruit, and the fleshy part of the fruit is pericarp. Lyon (1928) has found wheat seeds without embryos. Harlen and Pope (1925) found fruits in barley without embryos and others without endosperm.

SUMMARY OF GRASS EMBRYO SAC INVESTIGATIONS SINCE 1849

ANTIPODALS

	Tapetal Cell	Mega-spores	Embryo Sac	Number of Antipodals	Number of Nuclei	Lateral, or Chalazal	Fertilization	Endo-sperm	Author
1. BAMBUSEAE Bambusa bambos..........	None	Linear-T or T-form?	N. T.	60				Nu. E.	Schnarf, 1926
2. FESTUCEAE Briza media			N. T.	Many	Multinucleate				Fischer, 1880
Briza maxima				Many	Multinucleate	Lateral			Westermaier, 1890
Bromus villosus	None	Linear-T	N. T.	3–10		Lateral	Observed		Beck and Horton, 1932
Bromus marginatus	None	T-form	N. T.	3–10		Lateral	Observed		Beck and Horton, 1932
Bromus rubens	None	Linear-T	N. T.	3–10		Lateral	Observed		Beck and Horton, 1932
Dactylis glomerata			N. T.	5–8	2–3 nucleate				Shadowsky, 1926
Diplachne serotina			N. T.	8–14	Uninucleate	Lateral			Shadowsky, 1926
Eragrostis cilianensis	None	T-form	Fusion of micropylar nuclei	4–6	Uninucleate	Lateral	Observed	Nu. E.	Stover, 1936
Melica nutans	One		Scilla-T	3					Fischer, 1880
Melica altissima	One		Scilla-T	3					Fischer, 1880
Molinia coerulea			N. T.	11–43	Binucleate	Chalazal			Shadowsky, 1926
Poa annua			N. T.	12	2–4 nucleate	Lateral		Nu. E.	Golinski, 1893
Poa Pratensis		Linear-T	N. T.	3–6	Multinucleate	Lateral		Nu. E.	Nishimura, 1922, Anderson, 1927
Poa compressa		Linear-T	N. T.	3–5		Lateral		Nu. E.	Anderson, 1927

SUMMARY OF GRASS EMBRYO SAC INVESTIGATIONS SINCE 1849—[*Continued*]

	Tapetal Cell	Mega-spores	Embryo Sac	Number of Antipodals	Number of Nuclei	Lateral, or Chalazal	Fertilization	Endo-sperm	Author
3. HORDEAE Agropyrum repens	None	Linear-T	N. T.	10–16			Observed; polar nuclei did not fuse	Nu. E.	Mowery, 1929
Elymus arenarius			N. T.	6–12					Hofmeister, 1861, Fischer, 1880
Hordeum sativa distichum				Many		Lateral			Westermaier, 1890
Hordeum tetrastichum				Many					Golinski, 1893
Hordeum murinum				15		Lateral			Lotscher, 1905
Hordeum vulgare			N. T. (H)	6–20			Observed (H.)		Hofmeister, 1861, Lotscher, 1905
Lolium italicum				3	Multinucleate	Lateral			Westermaier, 1890
Lolium tremulentum				3	Multinucleate	Lateral			Westermaier, 1890
Nardus stricta	None	Linear-T	N. T.	Many			Parthenogenic		Coulon, 1923
Secale cereale			N. T. (H)	20		Lateral (H.)	Parthenogenic (Gaines & Aasel, 1926)		Hofmeister, 1858–61, Fischer, 1880, Golinski, 1893, Westermaier, 1890, Lotscher, 1905
Triticum compactum splendens	None	Linear-T	N. T.	36	Multinucleate	Lateral	Observed	Nu. E.	Koernicke, 1896
Triticum repens				10	2–3 nucleate				Lotscher, 1905
Triticum vulgare				Many	Multinucleate		Observed	Nu. E.	Hofmeister, 1861 (1)
	One	Linear-T	N. T.	36+		Lateral	Observed	Nu. E.	Jensen, 1918 (2)
			N. T.	4 (P)			Observed (P.)		Percival 1921 (3)
				8–12	Multinucleate				Golinski, 1893 (4)
Aegilops ovata			N. T.						Schnarf, 1926

SUMMARY OF GRASS EMBRYO SAC INVESTIGATIONS SINCE 1849—[*Continued*]

	Tapetal Cell	Mega-spores	Embryo Sac	Number of Antipodals	Number of Nuclei	Lateral, or Chalazal	Fertilization	Endo-sperm	Author
4. AVENEAE **Avena fatua**	None	Linear-T	N. T.	25–30	Multinucleate	Lateral		Nu. E.	Cannon, 1910
Avena sativa		Linear-T	N. T.	11–30	Multinucleate	Chalazal	Observed	Nu. E.	Tannert, 1905, Golinski, 1893
Avena pubescens				3	Uninucleate	Lateral			Lotscher, 1905
Avena flavescens			N. T.	5–16	Multinucleate	Lateral			Shadowsky, 1926
Koeleria cristata			N. T.	4	Multinucleate			Nu. E.	Fischer, 1880
5. AGROSTIDAE **Agrostis incana**				6	Binucleate	Lateral			Shadowsky, 1926
Alepecurus pratensis		Linear-T	N. T.	3	4-nucleate			Nu. E.	Fischer, 1880
Coleanthus subtilis	None	T-form	N. T.	3	Multinucleate			Nu. E.	Schnarf, 1926
Cornucopiae nocturnum (Agrostis perennans)	One		Scilla-T	3	Binucleate	Lateral		Nu. E.	Guignard, 1882
6. ZOYSIEAE **Tragus racemosus (Nazia)**			N. T.	3–5	Uninucleate	Lateral			Shadowsky, 1926
7. CHLORIDEAE **Chloris gayana**			N. T.	6	Multinucleate	Chalazal			Shadowsky, 1926
Cynodon dactylon			N. T.	6–10	Multinucleate	Lateral			Shadowsky, 1926
Eleusine indica			N. T.	3					Cummins, 1929
Sesleria coerulea (Bulbilis)		Linear-T	N. T.	3	Multinucleate	Chalazal			Fischer, 1880
8. PHALARIDEAE **Ehrharta panicea**			N. T.	3–6	Binucleate	Lateral			Fischer, 1880
9. ORYSEAE **Oryza sativa**			N. T.	3–Many	Multinucleate	Chalazal		Nu. E.	Kuwada, 1910
	None						Observed		Terada, 1928
10. ZIZANIEAE **Luzula pilosa (Luziola)**		Linear-T	N. T.	3					Fischer, 1880

SUMMARY OF GRASS EMBRYO SAC INVESTIGATIONS SINCE 1849—[*Continued*]

	Tapetal Cell	Mega-spores	Embryo Sac	Number of Antipodals	Number of Nuclei	Lateral, or Chalazal	Fertilization	Endo-sperm	Author
11. Melinideae									
12. Paniceae Paspalum dilatatum			N. T.	5–14	2–3 nucleate	Chalazal			Shadowsky, 1926
Oplismenus undulatifolium			N. T.	10–18	Binucleate	Chalazal			Shadowsky, 1926
13. Andropogoneae Andropogon caucasicum			N. T.	4–6	Uninucleate	Lateral			Shadowsky, 1926
Andropogon ischaemum			N. T.	5–16	Uninucleate	Chalazal			Shadowsky, 1926
Eulalia japonica (Miscanthus sinensis)			N. T.	15–24	2–3 nucleate	Chalazal			Shadowsky, 1926
Gynerium argenteum			N. T.	8–13	Uninucleate	Chalazal			Shadowsky, 1926
Sorghum bicolor				Many		Chalazal			Hofmeister, 1842
Sorghum helpense				4					Fischer, 1880 (1)
			N. T.	Many	Multinucleate				Hofmeister, 1861 (2)
							Observed		Stephens, 1934 (3)
Saccharum officinarum	None	Linear-T	N. T.	5	Multinucleate		Observed	Nu. E.	Artswager, 1929
14. Tripsaceae Coix lacryma			N. T.	3	Multinucleate	Chalazal			Hofmeister, 1861
Zea mays			N. T.	25		Chalazal			Hofmeister, 1849 (1)
			N. T.						Westermaier, 1890 (2)
			N. T.						Golinski, 1893 (3)
			N. T.						Guignard, 1901 (4)
			N. T.						Lotscher, 1905 (5)
	None	Lily-T	Lily-T				Observed	Nu. E.	Miller, 1920 (6)
	One	Linear-T	N. T.				Observed	Nu. E.	Weatherwax, 1919 (7)

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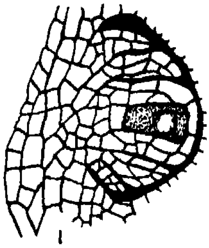

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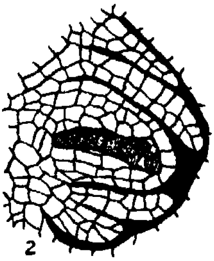

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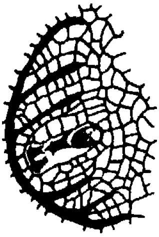

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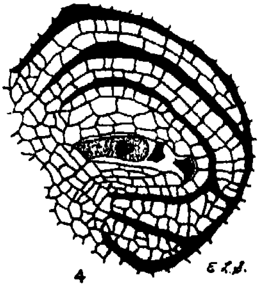

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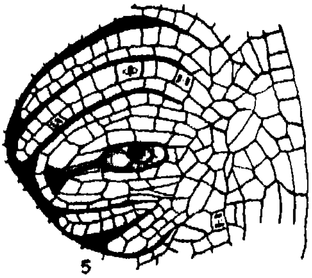

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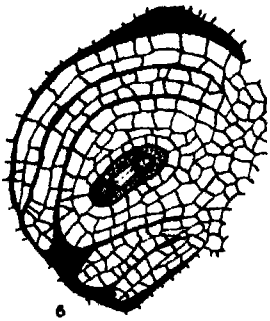
Fig. 1. Section of young ovule showing archesporial cell.

Figs. 2, 3, 4. Sections of young ovules showing T-form tetrad.

Fig. 5. Section of ovule showing persistence of the inner megaspore and the disintegration of the other megaspores.

Embryo Sac of Eragrostis
E. L. Stover

PLATE II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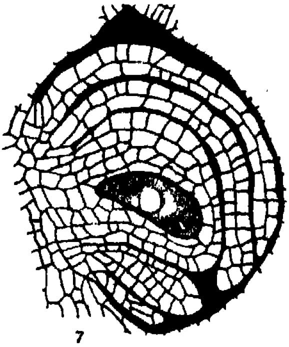
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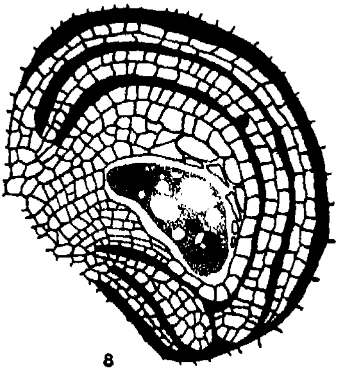
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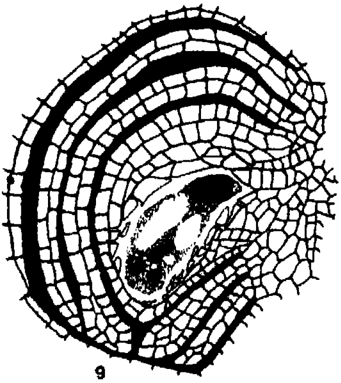
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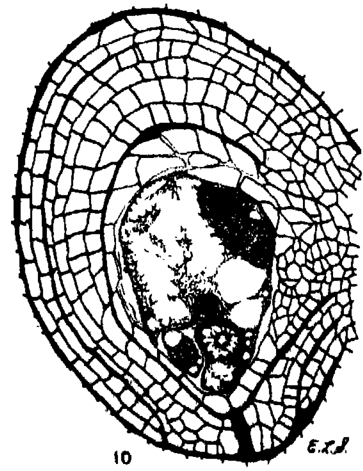

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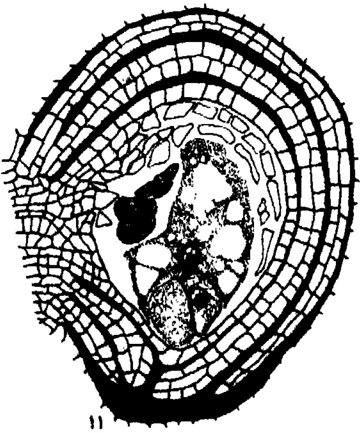
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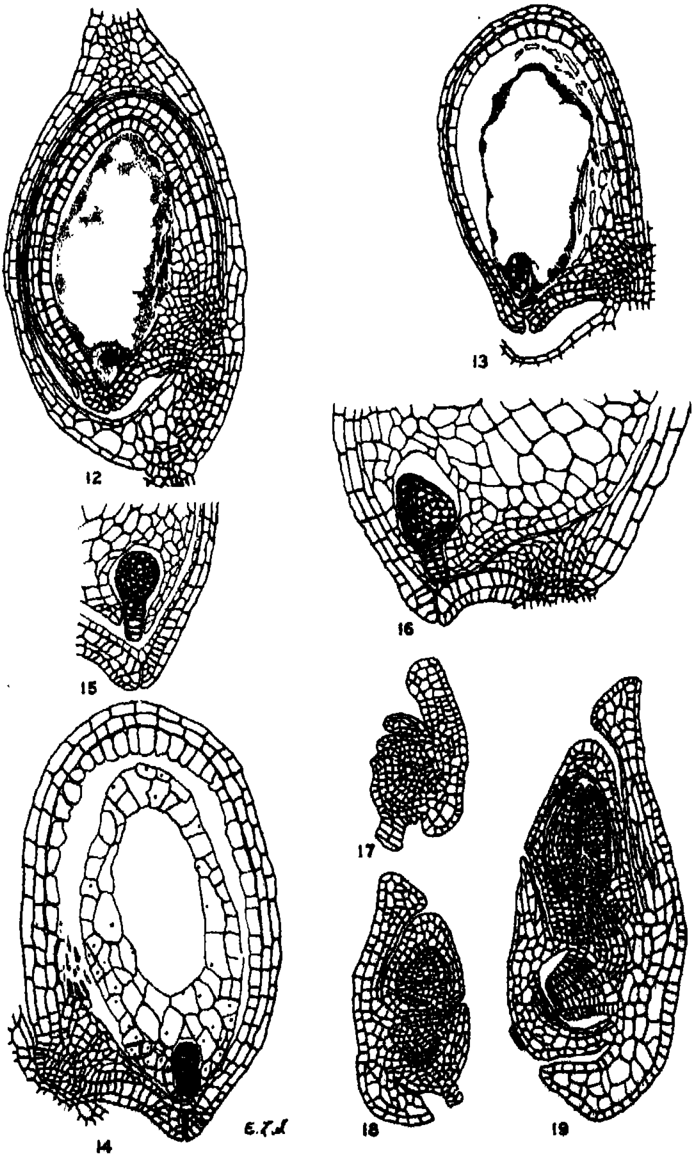
Figs. 6 and 7. The two and four nucleate embryo sacs.

Figs. 8 and 9. The eight nucleate sac showing the separation of all four antipodals from the rest of the sac.

Figs. 10 and 11. The maturing embryo sac; one synergid, the egg, and the fusion of two micropylar nuclei forming the endosperm nucleus; the antipodals remaining *in situ* as the sac enlarges.

Embryo Sac of Eragrostis
E. L. Stover

PLATE III



Figs. 12, 13, 14. Sections of ovule showing the fertilized egg and young embryo; the developing endosperm; antipodals in disintegrating stages; the disappearance of the outer integument.

Figs. 15–19. Development of the embryo.

AN ANNOTATED LIST OF THE DRAGONFLIES (ODONATA) OF OHIO

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This list is based on the collections made or examined by the writer during the last several years, and on the records in the literature. The list is doubtless incomplete, as there are some sections of the state that are as yet not adequately worked, but it was thought advisable to publish a preliminary list at this time since no such list has been published in the last 38 years.

The recorded distribution of each species in the state is given by counties. In counties where the writer has not collected the species recorded, the name of the collector is indicated by initials in parentheses following the county record. Records in the literature for counties in which the writer has not collected are similarly indicated. When the collector's initials are followed by an asterisk, specimens are in the writer's collection; otherwise the specimens are in the collection of the collector, or in a collection indicated by initials. When a county record is based on observation only (no specimens) the county name is written in *italics*. The dates following the list of counties are the earliest and latest dates of observation or capture of the species in Ohio.

The following abbreviations are used for collectors and collections:

AW—Alfred Wolf
BB—V. L. and M. J. Bristow
BEM—B. Elwood Montgomery
BPR—Ben P. Ramsey
CFW—Charles F. Walker
CHK—Clarence H. Kennedy
CU—Clem Uller
DJ—Dale W. Jenkins
DM—W. Donald Murray
DS—Dale Snavely
EB—Emerson Ball
EBW—E. B. Williamson
EMS—Earl M. Sprunger
EPB—E. P. Breakey
EPF—E. P. Fuchs
EST—Edward S. Thomas
FLJ—F. L. Jeffries
GG—Gene Good
GH—Gerald Huffman
GRO—George R. Owen
HAW—Harold A. Waters
HK—R. Henry Kyle
JAS—James A. Strasburg
JB—Joe Bailey
JGH—James G. Haub
JS—John Stanley

JSH—James S. Hine
JST—John S. Thomas
LB—Lawrence Beery, Jr.
LBa—Lorain Basinger
LOC—L. O. Clevenger
LYL—L. Y. Lancaster
MBT—Milton B. Trautman
MDN—Mary D. Neiswander
MDR—Mary D. Rogick
MEC—Meril E. Crago
NJG—N. J. Geiler
OSM—Ohio State (Natural History) Museum
OSU—Collection of Dept. Zoology and Entomology, Ohio State University
RCO—Raymond C. Osburn
REK—R. E. Kunze
RG—Robert Goslin
RTE—Ray T. Everly
SL—Simon Levine
UM—Collection of Museum of Zoology, Univ. of Michigan
WED—Weldon E. Diller
WFH—W. F. Henninger
WRP—William R. Piper

LIST OF SPECIES

Family AESCHNIDAE

1. *Tachopteryx thoreyi* Hagen.
Champaign, Fairfield (JSH, OSM), Guernsey (HAW*), Hocking, Summit (JSH, OSU). May 12 to Aug. 11.

2. *Negomphoides obscura* Rambur.[1]
Gallia, Lawrence (OSU). May 30 to June 23.

3. *Hagenius brevistylus* Selys.
Ashland (OSU), Delaware, Franklin, Holmes (EST, OSM). June 3 to Aug. 4.

4. *Ophiogomphus rupinsulensis* Walsh.
Franklin, Holmes (CFW, OSM), Portage (Osburn and Hine, 1900). May 17 to July 22.

5. *Erpetogomphus designatus* Hagen.
Hamilton (Hine, 1913). July 26.

6. *Gomphus (Gomphurus) abbreviatus* Hagen.
Ashland (Hine, 1900 and 1913). June 10 to June 23.

7. *Gomphus (Stylurus) amnicola* Walsh.
Hamilton (Hine, 1913). May 5 to July 25.

8. *Gomphus (Gomphurus) crassus* Hagen.
Delaware, Franklin. May 23 to June 13.

9. *Gomphus (Gomphus) exilis* Selys.
Erie (Hine, 1901), Franklin (Kellicott, 1899), Logan, Portage (EST*), Summit (JSH, OSM), Vinton. May 9 to July 19.

10. *Gomphus (Gomphurus) fraternus* Say.
Coshocton, Erie (BEM*), Franklin, Gallia, Logan (JSH, OSM), Ottawa (BEM), Portage (Osburn and Hine, 1900), Ross, Vinton (OSU). May 28 to July 8.

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[1] This species is placed in the genus *Negomphoides* on the authority of Cowley (1934, p. 244).

11. *Gomphus (Arigomphus) furcifer* Hagen.
Erie (OSU), Fairfield (Kellicott, 1899), Portage (Kellicott, 1899). June 14 to July 2.

12. *Gomphus (Gomphus) graslinellus* Walsh.
Auglaize, Delaware, Franklin, Greene (HK*), Hocking, Jackson, Licking, Logan, Union, Van Wert (GG). May 21 to July 1.

13. *Gomphus (Gomphurus) lineatifrons* Calvert.
Ashland (OSU), Franklin, Portage (Osburn and Hine, 1900, as *Gomphus dilatatus* Rambur). May 24 to June 14.

14. *Gomphus (Gomphus) lividus* Selys.
Auglaize (JAS), Erie (BEM), Fairfield, Gallia, Geauga (MEC*), Greene, Hocking (CFW, OSM), Holmes (JSH, OSM), Knox (EBW, UM), Lawrence (OSU), Licking, Monroe (CFW, OSM), Portage (Osburn and Hine, 1900), Sandusky (BEM). May 11 to July 14.

15. *Gomphus (Stylurus) notatus* Rambur.
Lawrence (OSU). May 30.

16. *Gomphus (Stylurus) plagiatus* Selys.
Erie (EBW, UM), Fulton (Kellicott, 1899), Ottawa (Kennedy, 1922). June 20 to July 1.

17. *Gomphus (Gomphus) quadricolor* Walsh.
Coshocton, Franklin (OSU), Portage (Osburn and Hine, 1900), Tuscarawas. May 30 to June 13.

18. *Gomphus (Gomphus) spicatus* Hagen.
Erie (OSU), Logan, Portage (Osburn and Hine, 1900). May 7 to June 11.

19. *Gomphus (Stylurus) spiniceps* Walsh.
Fairfield (Kellicott, 1899), Ottawa (BEM), Summit (OSU). June 27 to Sept. 26.

20. *Gomphus (Gomphurus) vastus* Walsh.
Coshocton, Erie (OSU), Franklin (OSU), Ottawa (BEM*), Seneca (DS). May 30 to Sept. 15.

21. *Gomphus (Gomphurus) ventricosus* Walsh.
Coshocton, Franklin. May 23 to May 30.

22. *Gomphus (Arigomphus) villosipes* Selys.
Franklin (OSU), Geauga (MEC*), Knox (GRO*), Perry (JSH, OSM), Sandusky, Summit (JSH, OSU). May 10 to June 17.

23. *Gomphus (Gomphurus) viridifrons* Hine.
Ashland (JSH, OSU—type), Coshocton (JSH*), Logan (JSH, OSM). June 10 to June 14.

24. *Dromogomphus spinosus* Selys.
Coshocton, Crawford (OSU), Erie (Hine, 1901), Franklin, Portage (Osburn and Hine, 1900). May 30 to June 28.

25. *Dromogomphus spoliatus* Hagen.
"Common in northwestern Ohio along the Maumee River and its tributaries, and the Ohio canal." (Kellicott, 1899, p. 73).

26. *Lanthus albistylus* Hagen.
Ashland (JSH, OSU), Delaware, Franklin. June 3 to June 13.

27. *Gomphaeschna furcillata* Say.
Franklin (OSU). June 13 to June 15.

28. *Basiaeschna janata* Say.
Delaware, Fairfield, Franklin, Fulton (JSH, OSM), Greene (HK*), Licking, Morrow, Portage (Osburn and Hine, 1900), Tuscarawas. May 4 to June 13.

29. *Boyeria grafiana* Williamson.
Ashtabula (OSU). Sept.

30. *Boyeria vinosa* Say.
Belmont (BPR*), Coshocton (DJ), Fairfield (RG, OSM), Franklin, Geauga (MEC*), Hocking (EST, OSM), Jackson, Knox (Williamson, 1907), Logan, Seneca (OSU). June 22 to Sept. 1.

31. *Anax junius* Drury.
Ashtabula (JSH, OSU), Auglaize (JAS), Champaign, Coshocton (DJ), ***Darke*** (DJ), Delaware (JCP), Erie (BEM), Fairfield, Franklin, Geauga, Greene (HK*), ***Holmes***, ***Jackson***, Lawrence, Licking, Logan, Lucas (JB*), Ottawa, ***Perry***, Pickaway, ***Pike***, Portage (Osburn and Hine, 1900), Putnam (WED*), Sandusky, Shelby, ***Vinton***, ***Washington***, Wayne. April 7 to Oct. 8.

32. *Anax longipes* Hagen.
Erie (OSU), Hamilton (Kellicott, 1899), ***Wayne*** (BEM). June 22 to July 25.

33. *Nasiaeschna pentacantha* Rambur.
Portage (OSU). June 1 to June 22.

34. *Epiaeschna heros* Fabricius.
Auglaize (WFH, OSM), Erie (Hine, 1901), Franklin (CHK*), Licking (SL*), Ottawa (MDR*), Portage (Osburn and Hine, 1900). April 25 to July 10.

35. *Aeschna clepsydra* Say.
Kellicott, 1899, p. 84. (No locality given.)

36. *Aeschna constricta* Say.
Erie (CU, UM), Franklin (OSU), Logan, Ottawa (Kennedy, 1922). Aug. 10 to Sept. 23.

37. *Aeschna mutata* Hagen.
Franklin, Ottawa (CHK*), Portage (OSU). June 10 to June 27.

38. *Aeschna umbrosa* Walker.
Allen (JAS), Butler (EBW*), Champaign, Columbiana (Walker, 1912), Coshocton (DJ), Franklin, Geauga (MEC*), Logan, Medina (OSU), Shelby (DM*), Summit (OSU). July 21 to Oct. 13.

39. *Aeschna verticalis* Hagen.
Erie (Hine, 1901), Franklin (OSU), Summit (OSU). Sept. 19 to Oct. 6.

40. *Cordulegaster diastatops* Selys.
Champaign, Geauga (MEC*), Licking, Portage (JAS*). May 21 to July 7.

41. *Cordulegaster erroneus* Hagen.
Fairfield (OSU), Hocking (JST, OSM). July 5 to July 30.

42. *Cordulegaster maculatus* Selys.
Hocking. June 2 to June 17.

43. *Cordulegaster obliquus* Say.
Ashtabula (Kellicott, 1899), Guernsey (AW*). June to July.

Family LIBELLULIDAE

44. *Macromia illinoiensis* Walsh.
Adams (JSH, OSM), Erie (JSH, UM), Franklin (JSH, OSU), Hocking, Morgan (MBT, OSM), Ottawa (Kennedy, 1922), Pike (JS*), Portage (Osburn and Hine, 1900), Ross, *Tuscarawas*. May 3 to Aug. 7.

45. *Macromia taeniolata* Rambur.
Henry (JSH, UM), Lucas (OSU). July 9 to Aug. 1.

46. *Didymops transversa* Say.
Franklin (OSU), Vinton. April 25 to June 6.

47. *Neurocordulia obsoleta* Say.
Hamilton (OSU). June 15.

48. *Neurocordulia yamaskensis* Provancher.
Erie (Hine, 1901), Ottawa (OSU). June 26 to June 28.

49. *Epicordulia princeps* Hagen.
Coshocton (DJ), Erie (OSU), Fairfield, Franklin (EMS*), *Holmes*, Licking, Logan, Ottawa (Kennedy, 1922), *Perry*, Portage (Osburn and Hine, 1900). June 2 to Sept. 14.

50. *Tetragoneuria cynosura* Say.
Ashtabula (DJ), Champaign (CHK), *Coshocton* (DJ), Delaware (Kellicott, 1899, as *T. semiaqua* Burm.), Erie (Hine, 1901), Fairfield, Franklin, Geauga (MEC*), Hamilton (Muttkowski, 1911), Knox (Muttkowski, 1911), Licking (MDN, OSM), Logan, Mahoning (Muttkowski, 1911), Muskingum, Perry, Portage (JSH, OSU), Vinton. May 18 to Aug. 10.

51. *Somatochlora hineana* Williamson.
Logan (Williamson, 1931; type locality). June 7 to July 4.

52. *Somatochlora tenebrosa* Say.
Champaign, Coshocton (DJ*), Hocking (JSH, OSM), Jackson (CFW, OSM). July 1 to Aug. 4.

53. *Nannothemis bella* Uhler.
Champaign. June 6 to Aug. 14.

54. *Perithemis tenera* Say.
Belmont (BPR*), Clark, Coshocton (DJ*), Darke (DJ*), Erie (BEM), Fairfield, Franklin, *Geauga*, Greene, Hamilton (JGH*), Holmes, Lawrence, Licking, Logan, Lucas (JB, UM), Ottawa, Portage, Sandusky, *Shelby*, *Trumbull*, Vinton. June 11 to Sept. 14.

55. *Celithemis elisa* Hagen.
Ashtabula (DJ*), Champaign (JB*), Clark, Erie (BEM*), Fulton (OSU), Logan, Ottawa (BEM), Portage (Osburn and Hine, 1900), Vinton, *Washington*. June 6 to Aug. 15.

56. *Celithemis eponina* Drury.
Champaign (JB, UM), *Clark*, Erie (OSU), Franklin (JAS), Geauga, Licking, Logan, Miami (EST, OSM), Portage (Osburn and Hine, 1900). June 13 to Aug. 10.

57. *Celithemis monomelaena* Williamson.
Franklin (Williamson, 1910), Hamilton (Williamson, 1910), Portage (OSU), Summit (OSU). June 18 to Aug. 23.

58. *Erythrodiplax minuscula* Rambur.
Vinton. June 23.

59. *Erythrodiplax umbrata* Linnaeus.
Champaign. June 11.

60. *Ladona julia* Uhler.
Portage (OSU). June 18 to June 22.

61. *Libellula* (*Holotania*) *auripennis* Burmeister.
Hamilton (Kellicott, 1899), *Vinton*. June 23.

62. *Libellula* (*Holotania*) *cyanea* Fabricius.
Knox (OSU), Vinton. June 6 to July 12.

63. *Libellula* (*Holotania*) *incesta* Hagen.
Erie (OSU), Geauga, Portage (Osburn and Hine, 1900). June 26 to Aug. 1.

64. *Libellula* (*Holotania*) *luctuosa* Burmeister.
Ashtabula (DJ*), Belmont (BPR*), Champaign (JB, UM), *Clark*, Coshocton (DJ*), Darke (DJ*), Delaware, Erie (BEM*), Fairfield, Franklin, Geauga, Greene, *Holmes*, Jackson (EST, OSM), Licking, Logan, Lucas (JB, UM), Mahoning, Marion (BEM), *Miami*, Ottawa (Kennedy, 1922), Pike (CFW, OSM), Portage (EST, OSM), *Ross*, Sandusky, *Stark*, Trumbull, Van Wert (GG), Vinton. May 28 to Sept. 11.

65. *Libellula* (*Plathemis*) *lydia* Drury.
Adams, Ashtabula, Auglaize, Belmont (BPR*), Carroll, Champaign, *Clinton*, Coshocton (FLJ), Delaware, Erie, Fairfield, *Fayette*, Franklin, *Gallia*, Geauga, Greene, *Guernsey*, Hocking, Knox (GRO*), Licking, Logan, Lucas (JB, UM), Mahoning, Marion (BEM), Mercer, Montgomery, Morrow (REK), Muskingum (JST, OSM), Ottawa, Pickaway, Portage (Osburn and Hine, 1900), Ross, Sandusky, Shelby, *Stark*, Van Wert (GG), Vinton, *Washington*. May 13 to Aug. 30.

66. *Libellula* (*Neotetrum*) *pulchella* Drury.
Adams, *Ashland*, Ashtabula, *Auglaize*, Belmont (BPR*), *Carroll*, Champaign, *Clark*, *Coshocton* (DJ), *Darke* (DJ), Delaware, Erie, Fairfield, *Fayette*, Franklin, Geauga, Greene, Hocking, Holmes, Jackson, Knox, Lawrence, Licking, Logan, Lucas (JB, UM), *Mahoning*, Marion (BEM), Mercer, Ottawa, Pickaway, *Pike*, Portage (Osburn and Hine, 1900), Putnam (LBa), Ross (EPF), Sandusky, Scioto, Shelby, Summit (LB), Trumbull, Van Wert (GG), Vinton, *Washington*, Wayne (BEM). May 9 to Aug. 30.

67. *Libellula* (*Libellula*) *quadrimaculata* Linnaeus.
Erie (OSU), Knox (Hine, 1899). June 12 to June 22.

68. *Libellula* (*Eolibellula*) *semifasciata* Burmeister.

Ashtabula (DJ*), Champaign, Erie (OSU), Fairfield, Franklin, Hocking, Ottawa (Kennedy, 1922), Portage (Osburn and Hine, 1900), Vinton. May 2 to July 15.

69. *Libellula* (*Holotania*) *vibrans* Fabricius.

Fairfield (Kellicott, 1899), Franklin (OSU), Logan (JSH, OSM). June to July.

70. *Sympetrum ambiguum* Rambur.

Champaign, Erie, Fairfield, Franklin, *Holmes*, Licking, Logan, Ottawa, Perry (EST, OSM), Shelby. July 1 to Sept. 10.

71. *Sympetrum corruptum* Hagen.

Ashtabula, Erie (BEM), Franklin, Fulton (OSU), Greene (HK*), Licking, Putnam (WED*). April 18 to Aug. 9.

72. *Sympetrum obtrusum* Hagen.

Ashtabula, Erie (OSU), Franklin, Licking (JSH), Logan, Lucas (JB, UM), Ottawa, Scioto (OSU), Shelby, Vinton. June 23 to Sept. 9.

73. *Sympetrum rubicundulum* Say.

Ashtabula, Champaign, Coshocton (EPB*), Erie (OSU), Fairfield, Franklin, Geauga, Highland (JSH, OSM), Licking, Logan, Lucas (JB, UM), Morrow (RTE*), Ottawa, Perry (EST, OSM), Portage (Osburn and Hine, 1900), Sandusky, Shelby, Stark, Summit (OSM), Vinton. June 10 to Aug. 26.

74. *Sympetrum semicinctum* Say.

Belmont (BPR*), Champaign, Erie (OSU), Franklin (Kellicott, 1899), Geauga, Logan, Lucas (JB, UM), Summit (JSH, OSM). July 2 to Aug. 26.

75. *Sympetrum verum* Bartenef.

"Ohio." (Bartenef, 1915.)

76. *Sympetrum vicinum* Hagen.

Athens (EB), Butler (EBW*), Champaign, Coshocton (EPB*), Erie (BEM*), Fairfield (JAS), Franklin, Geauga, Holmes, Licking (JSH, OSM), Logan, Ottawa, Perry (EST, OSM), Portage, Trumbull, Vinton, Washington. June 29 to Nov. 7.

77. *Leucorrhinia intacta* Hagen.

Champaign, Erie (BEM*), Franklin, Geauga, Licking, Logan, Ottawa (Kennedy, 1922), Portage (JSH, OSM). May 9 to Aug. 1.

78. *Pachydiplax longipennis* Burmeister.

Ashtabula, Auglaize, Champaign, Coshocton, Delaware, Erie (BEM), Fairfield, Franklin, Geauga, Greene, Hocking, Holmes, Lawrence, Licking, Logan, Lucas (JB, UM), Miami (EST, OSM), Morrow (REK), Muskingum (JST, OSM), Ottawa, Perry (EST, OSM), Pickaway, *Pike*, Portage (Osburn and Hine, 1900), Sandusky, Shelby, *Trumbull*, Vinton, Washington. May 6 to Sept. 9.

79. *Erythemis simplicicollis* Say.

Champaign (JB, UM), *Clark*, Coshocton (DJ*), *Darke* (DJ), Erie (BEM), Fairfield, Franklin, Greene (HK*), Holmes, Licking, Logan, Lucas (JB, UM,) Miami (EST, OSM), Ottawa, Perry, Portage (JAS), Sandusky, Shelby, Stark, *Trumbull*, Vinton. May 19 to Oct. 16.

80. *Pantala flavescens* Fabricius.
Ashtabula, Erie (Hine, 1901), Fulton (OSU), Logan (DM), Pickaway (LOC), Ottawa (OSU). July 2 to Oct. 17.

81. *Pantala hymenaea* Say.
Adams, *Athens*, Franklin (LOC), Logan (MBT, OSM), Shelby (Kellicott, 1899), ***Washington***. April 3 to June 29.

82. *Tramea carolina* Linnaeus.
Clark, Erie (Hine, 1901a), Franklin, ***Licking***, Ottawa, Vinton, ***Washington***. May 6 to Aug. 14.

83. *Tramea lacerata* Hagen.
Ashtabula (DJ), Champaign, *Clark*, *Coshocton* (DJ), Delaware, Erie (BEM*), Fairfield, Franklin, Greene, ***Holmes***, ***Jackson***, Licking, Logan, Lucas (JB, UM), Ottawa, Perry, Pickaway, Pike, Portage (Osburn and Hine, 1900), Vinton, ***Washington***. May 6 to Oct. 11.

84. *Tramea onusta* Hagen.
Cuyahoga (OSU), Erie, Franklin (JS), Greene (HK*), Hamilton (Kellicott, 1899), Ottawa. May 7 to Aug. 26.

Family CALOPTERYGIDAE

85. *Calopteryx aequabile* Say.
Portage (OSU), Summit (OSU). June 18 to June 26.

86. *Calopteryx angustipenne* Selys.
Ashland (OSU). June 10 to June 14.

87. *Calopteryx maculatum* Beauvais.
Adams, Ashland, Ashtabula, Auglaize, Champaign, Clark, Clinton, Coshocton, Delaware, Erie (BEM*), Fairfield, Franklin, Gallia, Geauga (MEC*), Greene, Guernsey, Hamilton (Huggins, 1927), Highland, Hocking, Holmes, Jackson, Lake (BEM), Licking, Logan, Lucas (JB, UM), Marion (BEM), Morrow, Perry, Portage, Ross, Trumbull, Union, Vinton, Wayne (BEM). May 21 to Aug. 18.

88. *Hetaerina americana* Fabricius.
Ashland, Auglaize, Belmont (BPR*), Champaign (JB, UM), Clark, Delaware, Erie (BEM*), Fayette, Franklin, Greene, Highland, Hocking, Lake (BEM), Licking, Logan, Madison, Mahoning, Paulding (GG), Portage (Osburn and Hine, 1900), Ross, Scioto (OSU), Shelby, Summit (LB). May 7 to Oct. 7.

89. *Hetaerina titia* Drury.
Fairfield (OSU). Sept. 28.

Family COENAGRIONIDAE

90. *Archilestes grandis* Rambur.
Butler (Williamson, 1930), Preble (EST, OSM), Montgomery (Cotterman, 1930). Sept. 21 to Oct. 11.

91. *Lestes congener* Hagen.
Franklin (OSU), Licking (JSH, OSM), Logan. July 3 to Sept. 28.

92. *Lestes disjunctus* Selys.

Ashtabula, Columbiana (EBW, UM), Delaware (GH), Erie (RCO, UM), Fairfield, Franklin, Geauga (MEC*), Ottawa (UM). May 9 to Aug. 14.

93. *Lestes eurinus* Say.

Erie (OSU), Franklin, Logan, Portage (Hine 1900 and 1913). May 24 to July 14.

94. *Lestes forcipatus* Rambur.

Ashtabula, Auglaize (JAS), Champaign, Erie (OSU), Fairfield, Franklin, Hocking (JST, OSM), Knox (GRO*), Lawrence, Logan, Lucas (JB, UM), Ottawa, Portage (JSH, UM). April 28 to Aug. 18.

95. *Lestes inaequalis* Walsh.

Champaign (JB*), Erie (OSU), Fairfield (OSU), Licking (WRP*), Logan (WRP*), Morrow (REK), Portage (RCO, UM), Stark. June 16 to Aug. 10.

96. *Lestes rectangularis* Say.

Ashtabula, Champaign, Coshocton, Erie, Fairfield, Franklin, Geauga, Greene, Holmes, Knox (EBW, UM), Licking, Logan, Lucas (JB*), Muskingum (DJ), Ottawa, Portage, Sandusky, Shelby, Stark, Trumbull, Vinton, Washington. May 30 to Aug. 26.

97. *Lestes uncatus* Kirby.

Ashtabula, Champaign, Coshocton (JSH, OSM), Erie (BEM), Fairfield, Franklin, Geauga, Logan, Lucas (JB, UM), Mahoning (UM), Morrow (REK), Ottawa (Kennedy, 1922), Portage (JSH, UM). June 10 to Aug. 1.

98. *Lestes unguiculatus* Hagen.

Ashtabula, Champaign, Erie (OSU), Franklin, Logan, Ottawa, Summit (LB), Trumbull. July 1 to Aug. 22.

99. *Lestes vigilax* Hagen.

Erie (OSU), Portage. July 4 to Aug. 1.

100. *Argia apicalis* Say.

Adams, Athens, Auglaize, Belmont (BPR*), Delaware, Erie (BEM*) Fairfield, Franklin, Gallia, Greene, Licking, Logan, Lucas (JB, UM), Mahoning, Montgomery, Muskingum, Ottawa, Portage (Osburn and Hine, 1900), Ross, Sandusky, Scioto (NJG), Shelby, Stark, Summit (LB), Vinton. June 4 to Sept. 4.

101. *Argia bipunctulata* Hagen.

Champaign. June 3 to Aug. 22.

102. *Argia moesta* Hagen.

Adams, Ashland, Belmont (BPR*), ***Clark***, ***Coshocton***, Delaware (DM), Erie (BEM), Fairfield, Franklin, Greene, Highland, Holmes (EST, OSM), ***Hocking***, Knox, Lake (BEM), Licking, Logan, Mahoning, Miami, ***Montgomery***, Ottawa, Portage (Osburn and Hine, 1900), Ross, Shelby, Tuscarawas, Van Wert (GG). May 30 to Aug. 24.

103. *Argia sedula* Hagen.

Adams, Athens, Erie (Hine, 1901), Fayette, Franklin, Fulton (OSU), Greene, Hocking, Knox (FLJ), Licking, Madison, Ross, Shelby. June 12 to Aug. 24.

104. *Argia tibialis* Rambur.
Adams, Athens, Delaware, Erie (BEM), Fairfield, Franklin, Gallia, Greene, Highland, *Hocking*, *Holmes*, Jackson, Knox (FLJ), Licking, Logan, Montgomery, Pickaway, Portage (Osburn and Hine, 1900), Ross, Sandusky, Trumbull, Vinton. May 30 to July 29.

105. *Argia violacea* Hagen.
Adams, Ashland, Ashtabula, Auglaize, Champaign, Clark, Clinton, Delaware, Erie (BEM), Fairfield, Franklin, Geauga, Greene, Highland, Holmes, Knox, Lake (BEM), Licking, Logan, Mahoning, Miami, Morrow, Perry, Pickaway, Portage, Ross, Sandusky, Stark, Trumbull, Vinton, Wayne (BEM). May 26 to Sept. 15.

106. *Amphiagrion saucium* Burmeister.
Champaign, Coshocton, Delaware, Erie (BEM), Fairfield, Franklin, Fulton (OSU), Geauga (MEC*), Hocking, Knox, Licking, Logan, Pickaway, Portage (JST, OSM), Wayne (BEM). May 10 to Aug. 13.

107. *Nehalennia gracilis* Morse.
Champaign, Geauga, Knox, Licking. May 30 to Aug. 1.

108. *Nehalennia irene* Hagen.
Ashtabula, Champaign, Erie (Hine, 1901a), Franklin, Licking, Logan, Ottawa (Kennedy, 1922), Portage (Osburn and Hine, 1900), Wayne (BEM*). May 17 to Aug. 1.

109. *Chromagrion conditum* Hagen.
Champaign, Delaware, Franklin, Geauga (MEC*), Greene, Licking, Ottawa (CHK), Portage (Osburn and Hine, 1900), Vinton. May 20 to July 12.

110. *Enallagma antennatum* Say.
Auglaize, Clark, Clinton, Delaware, Erie, Fairfield, Fayette, Franklin, Greene, Knox, Licking, Logan, Lucas (JB, UM), Mercer, Morrow, Muskingum, Perry, Portage (JSH, OSM), Sandusky, Shelby, Union, Wayne (BEM). May 20 to Aug. 11.

111. *Enallagma aspersum* Hagen.
Erie (OSU), Franklin, Geauga, Lawrence, Logan, Washington. May 7 to Aug. 1.

112. *Enallagma boreale* Selys.
Erie (BEM), Franklin. May 14 to June 20.

113. *Enallagma carunculatum* Morse.
Auglaize, Champaign, Clark, Erie (OSU), Holmes, Licking, Logan, Lucas (JB*), Mercer (Kellicott, 1899), Ottawa, Portage (Osburn and Hine, 1900), Stark. June 3 to Sept. 11.

114. *Enallagma civile* Hagen.
Ashtabula, Belmont (BPR*), Butler (EBW, UM), Clark, Darke (DJ*), Delaware, Erie, Fairfield, Fayette, Franklin, Greene, Holmes, Knox (GRO*), Licking, Logan, Lucas (JB, UM), Ottawa, Portage (Osburn and Hine, 1900), Sandusky, Tuscarawas, Washington. May 4 to Oct. 11.

115. *Enallagma divagans* Selys.
Clinton, Delaware, Fairfield, Greene, Jackson, Logan, Morrow, Portage (JSH, OSM), Vinton. June 3 to June 29.

116. *Enallagma doubledayi* Selys.
Franklin (OSU). May 4.[1]

117. *Enallagma ebrium* Hagen.
Erie (BEM), Franklin, Geauga (MEC), Logan (JSH, OSM), Ottawa (BEM*), Portage (JSH, OSM), Sandusky. May 7 to July 15.

118. *Enallagma exsulans* Hagen.
Adams, Ashland, Athens, Auglaize, Butler (EBW, UM), Clark, Clinton, Delaware, Erie, Fairfield, Fayette, Franklin, Greene, Highland, *Hocking*, Jackson, Lake (BEM), Knox, Licking, Logan, Lucas (JB, UM), Madison, Mahoning, Miami, Montgomery, Morrow, Muskingum, Ottawa, Perry, Pickaway, Portage (Osburn and Hine, 1900), Ross, Sandusky, Stark, Trumbull, Tuscarawas, Union, Van Wert (GG), Vinton. May 17 to Sept. 4.

119. *Enallagma geminatum* Hagen.
Champaign (JB, UM), Erie (Hine, 1901), Franklin, Fairfield, Holmes, Licking, Logan, Perry, Portage (Osburn and Hine, 1900), Stark, Summit. May 14 to Sept. 26.

120. *Enallagma hageni* Walsh.
Franklin, Geauga (MEC*), Logan, Ottawa (Kennedy, 1922), Portage (JSH, OSM). June 11 to June 29.

121. *Enallagma signatum* Hagen.
Ashtabula, Champaign, Erie (BEM), Fairfield, Franklin (JAS), Holmes, Licking, Logan, Madison, Ottawa, Portage (Osburn and Hine, 1900), Shelby, Stark, Summit. May 21 to Sept. 26.

122. *Enallagma traviatum* Selys.
Fairfield (DJ*), Hamilton (OSU), Licking, Logan, Portage, Summit (Kellicott, 1899). June 1 to Aug. 1.

123. *Enallagma vesperum* Calvert.
Champaign (BB*), Erie (OSU), Greene, Licking, Logan, Ottawa, Portage (Osburn and Hine, 1900, as *E. pollutum* Hagen), Stark. May 31 to Aug. 25.

124. *Ischnura posita* Hagen.
Ashtabula, Butler (EBW, UM), Champaign, Clinton, Coshocton, Erie (BEM), Fairfield, Fayette, Franklin, Geauga, Greene, Holmes, Jackson, Lawrence, Licking, Logan, Madison, Montgomery, Morrow (DJ*), Muskingum, Perry, Pickaway, Portage (Osburn and Hine, 1900, as *Nehalennia posita*), Shelby, Summit, Union, Vinton, Wayne (BEM). April 23 to Oct. 11.

125. *Ischnura prognatha* Hagen.
Hocking (CHK, OSU). April 20.

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[1] This species was reported from Logan County in my 1930 paper (Borror, 1930, p. 415), but the specimens were misidentified. They were *E. carunculatum* Morse.

126. *Ischnura verticalis* Say.

Ashtabula, Auglaize, Belmont (BPR*), Butler (EBW, UM), Champaign, Clark, Clinton, Coshocton, Darke (DJ*), Delaware, Erie, Fairfield, Fayette, Franklin, Gallia, Geauga, Greene, Hocking, Holmes, Jackson, Knox, Lake (BEM), Licking, Logan, Lucas (JB*), Madison, Mahoning, Mercer, Miami, Morrow, Muskingum, Ottawa, Perry, Pickaway, Pike, Portage, Ross, Sandusky, Shelby, Stark, Summit, Trumbull, Tuscarawas, Union, Van Wert (GG), Vinton, Washington, Wayne (BEM). April 30 to Oct. 11.

127. *Anomalagrion hastatum* Say.

Champaign, Erie (BEM), Fairfield, Franklin, Fulton (OSU), Logan, Ottawa (LYL), Pike, Shelby, Vinton. May 6 to Aug. 24.

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BOOK NOTICES

Queen Becomes Handmaiden

Eric Temple Bell, who several years ago wrote a delightful treatise on mathematics, entitled "The Queen of the Sciences," has now written an account of mathematics from a different viewpoint. This he calls "The Handmaiden of the Sciences." It is quite as delightful as his older books, though not so easy to read. Numerous examples are given of the predictive ability of mathematics in the natural sciences. The calculus is extensively treated, and some consideration is given to geometry, waves and vibrations, and probability. Throughout the book the place of mathematics in serving, stimulating and predicting for the sciences is emphasized. Although the reader is frequently exasperated by the fact that he is never quite sure when the author is serious and when he is laughing at him, the book is highly recommended to scientists for its informative entertainment.—L. H. S.

The Handmaiden of the Sciences, by Eric Temple Bell. viii+216 pp. Baltimore, The Williams and Wilkins Co., 1937. $2.00.

Weather

A much-needed, up-to-date textbook in meteorology, serving ideally the needs of the modern elementary college course in this country, has arrived in "Weather Elements," by Thomas A. Blair. The author, who is an experienced meteorologist with the United States Weather Bureau, as well as Assistant Professor of Meteorology at the University of Nebraska, has keenly sensed the problem of presenting the science of the weather before an average, non-specialized reader, and has written his work in a fascinating, though scientific language, stripped of highly technical phrases and mathematical equations. The work is distinctly modern as demonstrated by the inclusion of aeronautical information, latest developments in researches of the stratosphere, and principles of air-mass analysis and their application in weather forecasting. It is quite complete, though void of excessive descriptive matter. It is reasonably well illustrated, with a series of excellent cloud photographs as a feature. Four useful appendices include a well-rounded bibliography, and various tables and charts. The two short chapters dealing with climate might well have been omitted, at least from the viewpoint of the teacher of courses in that field.—PARIS B. STOCKDALE.

Weather Elements—A Textbook in Elementary Meteorology, by Thomas A. Blair. xv+401 pp., 107 figs. New York, Prentice-Hall, Inc., 1937. $4.00.

Elementary Electricity

"Electricity and Magnetism" is a textbook which should serve excellently as a text for a beginning course in Electrical Engineering or as a replacement for these topics in the ordinary course in College Physics.

The book is typical of English texts in the wealth of material covered and the clarification of written material by the use of solved examples. In the latter part of the work a slight knowledge of the elementary calculus is indicated, but the parts which embody these necessities may be omitted in a class not so prepared.

It might have been better if the first chapter (an introduction to supply the student with mechanical principles) had been omitted. This chapter contains a discussion of dimensions never mentioned again in the entire work, and without any use (so far as I can see) in an electrical problem, where their introduction always seems to be artificial, and serves at best as a poor check on the results which must be obtained in some other way.

The explanations and the solutions of the examples are very clear and the book appears to be very teachable. There is an excellent index and a large number of problems whose answers are given in a supplement at the end of the book.

—J. B. GREEN.

Electricity and Magnetism, by A. W. Hirst. xv+388 pp. New York, Prentice-Hall, Inc., 1937. $4.50.

Relativity

Relativity Theory of Protons and Electrons is the title of a highly entertaining new book by an author who needs no introduction, in which a theory is presented which aims to combine the concepts of the relativity and the quantum theories. The author has sought in his work to develop anew the theory of relativity along lines indicated by Diarc in his work which led to the relativistically invariant wave equation. The result has been, the author feels, an "harmonization rather than a unification" of the two theories.

The contents are divided into parts I and II, devoted in a general way to a development of the mathematical formalism and an application to physical problems respectively. This division, however, is a rather loose one since already in part I much physics has been anticipated. Part II concentrates itself largely about the problem of the origin of the "four required constants of nature:" (1) the ratio of the masses of the proton and the electron; (2) the fine structure constant; (3) the gravitational constant and (4) the number of particles in the universe. Numerical values are obtained for these in Chapters XII, XIV, XV and XVI, which appear to be in agreement with observation.

The book is important and desirable primarily because it presents this theory, much of which has been discussed earlier by the author in a series of papers in the Proceedings of the Royal Society, for the first time as a connected and homogeneous unit.—H. H. NIELSEN.

Relativity Theory of Protons and Electrons, by Sir Arthur Eddington. vi+336 pp. Cambridge, at the University Press; in New York, The Macmillan Co., 1936. $5.50.

Part Two of Peterson's Manual Completed

In 1934 Professor Alvah Peterson, of the Ohio State University, published Part I of his "Manual of Entomological Equipment and Methods." This first part dealt largely with equipment, most of which was diagramed, and with definite references to the sources. The extreme care and completeness with which Dr. Peterson prepared this first volume made it exceptionally valuable to all persons interested in any phase of entomology. Since its appearance entomologists have been eagerly awaiting the publication of Part II.

This second volume deals primarily with the rearing of insects. All of the literature upon this subject appearing in the English language has been consulted and abstracted under the names of the authors. One noteworthy feature of these abstracts is that they are of sufficient length to give a fairly comprehensive idea of the methods as described in the original articles. A second division of the volume gives twenty-one full page plates of special equipment as used in the articles abstracted. These are well drawn, clear and distinctly labelled. Besides rearing methods there has been included a number of related topics such as: killing, mounting, marking, shipping, etc.

To make the great mass of abstracts most usable the author has prepared a double index. Part A of this index is based upon the names of all the forms of insects, common and scientific, that are discussed in the abstracts. Part B is based upon the kinds of materials and equipment and the methods employed in the rearing. With the alphabetical arrangement of the authors this makes reference work very easy.

While either of these parts is of value to those working in special fields it is difficult to see how anyone working with insects can afford to be without the set of two volumes.—D. F. MILLER.

A Manual of Entomological Equipment and Methods, Part II, by Alvah Peterson. 334 pp. St. Louis, John S. Swift Co., Inc., 1937.

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1937

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B. *Botany:* Raymond A. Dobbins
C. *Geology:* John L. Rich
D. *Medical Sciences:* Bruce K. Wiseman
E. *Psychology:* Harold E. Burtt
F. *Physics and Astronomy:* Dayton C. Miller
G. *Geography:* Frank J. Wright
H. *Chemistry:* W. Conrad Fernelius

Secretary

William H. Alexander

Treasurer

Eugene Van Cleef

Executive Committee

Ex-Officio: Charles G. Shatzer, Wm. H. Alexander, Eugene Van Cleef
Elective: Charles A. Doan, A. W. Lindsey

Board of Trustees

Herbert Osborn, *Chairman*, term expires	1938
William Lloyd Evans, term expires	1939
James P. Porter, term expires	1940

Committee on Publications

Edward L. Rice, *Chairman*, term expires	1938
F. C. Dockeray, term expires	1938
Grace A. Stewart, term expires	1938

Library Committee

Mrs. Ethel M. Miller, *Chairman*,
In charge of Academy Exchanges and Publications

F. O. Grove, term expires	1938
W. H. Shideler, term expires	1939
L. B. Walton, term expires	1940

Committee on State Parks and Conservation

Edward S. Thomas, *Chairman*, term expires	1940
G. W. Conrey, term expires	1938
E. L. Wickliff, term expires	1938
Arthur T. Evans, term expires	1938
Emery R. Hayhurst, term expires	1939
Edmund Secrest, term expires	1939
L. E. Hicks, term expires	1939
F. H. Krecker, term expires	1940
W. E. Stout, term expires	1940

Academy Representatives on the Joint Administrative Board, Ohio Journal of Science

Edward L. Rice, term expires	1939
C. G. Shatzer, term expires	1938

Nominating Committee for 1938

A. A. W. Lindsey
B. C. E. O'Neal
C. Fred Foreman
D. R. A. Knouff
E. G. C. Myers
F. G. E. Owen
G. R. B. Frost
H. C. E. Boord

REPORT OF THE FORTY-SEVENTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

WILLIAM H. ALEXANDER,
Secretary

INTRODUCTORY

The Forty-seventh Annual Meeting of the Ohio Academy of Science was held at Columbus on May 13th–15th, 1937, under the joint auspices of the Ohio State and Capital Universities. The attendance was good, the programs were excellent and well attended, and a fine spirit prevailed generally.

The meetings of the Academy proper began on Friday morning, May 14, and were held in the auditorium of Mees Hall, Capital University. These meetings were given over, first, to business, and second, to a general scientific session. The chief items of business were the election of 39 new members, the adoption of a preliminary plan for the fitting observance of the semi-centennial of the organization of the Academy three years hence, the selection of the College of Wooster as the place of the next (1938) annual meeting, the approval of the annual reports of the officers and committees, the election of officers and a nominating committee for the ensuing year, and the adoption of an amendment to the Constitution and By-Laws.

The scientific session was notably attractive, consisting of three really outstanding features: First, an illustrated address on "Scientific Research in the Antarctic" by Dr. F. A. Wade of Miami University; second, two reels of moving pictures showing "High Speed Moving Pictures of Selected Biological and Physical Phenomena" secured and presented by Dr. Alpheus W. Smith; and third, an illustrated address on "Certificates of Growing Up and Growing Old" by Dr. T. Wingate Todd of Western Reserve University.

The annual dinner on Friday evening at the Faculty Club, Ohio State University, was, by common consent, the climax of the meeting. The accommodations were ample, the food and service elegant, and the intellectual offerings brilliant and stimulating. Dr. Laurence H. Snyder served as toastmaster most acceptably, President George W. Rightmire of Ohio State University and President Otto Mees of Capital University spoke pleasing words of welcome to which President Doan of the

Academy responded briefly, and then followed the *Presidential Address* on "Modern Medicine—the Crossroads of the Social and Physical Sciences." In this address President Doan has made a notable contribution to scientific literature and it should receive widespread publication. The second address of the evening on "Science and Higher Learning" was made by Dr. Otis W. Caldwell, the genial and popular general secretary of the American Association for the Advancement of Science, and fitted the occasion perfectly.

As indicated elsewhere in these proceedings, the 161 or so papers and addresses presented in the various sectional meetings covered a wide range and great variety of topics, a few of the sectional programs extending into Saturday afternoon.

MINUTES OF THE BUSINESS AND GENERAL SCIENTIFIC SESSIONS

Mees Hall, Capital University

(Stenographically reported by Wm. H. Howard)

Friday Morning, May 14, 1937

The meeting was called to order at 9 o'clock by President Charles A. Doan, of Ohio State University.

PRESIDENT DOAN: Because of the number and importance of the scientific reports to be submitted, the Executive Committee thought it would be advisable to handle the business affairs of the Association this morning. In this connection, of course, we will have a short business session, including the Nominating Committee's report for officers for next year. We wish to omit the Saturday morning business meeting so as not to interfere with the regular sectional programs tomorrow. Likewise, as many visitors will be present at the banquet tonight, we want to reduce to a minimum the business affairs of the Society at that time.

The personnel of the three committees to be announced at this time will be as follows:

Membership—K. G. A. Busch, Eugene Van Cleef, Samuel Allen.

Resolutions—H. H. M. Bowman, Walter H. Bucher.

Necrology—E. N. Transeau, Raymond C. Osburn.

We would like to have reports from these committees at the close of this morning's session. We now come to the official reports of our Secretary and Treasurer. I shall ask our Secretary, Mr. Alexander, to submit his report.

(Mr. Alexander then read his report.)

PRESIDENT DOAN: I would like to take this occasion to express my own appreciation in helping with the duties of the Secretary's office and the personal pleasure it has been to cooperate with Mr. Alexander in planning for this meeting this year. What will you do with the Secretary's report?

A motion prevailed to place the report on record.

PRESIDENT DOAN: We shall now have the Treasurer's report.

DR. A. E. WALLER, Treasurer: I was asked to make this report brief.

(Dr. Waller read the report. Printed elsewhere.)

PRESIDENT DOAN: What is the pleasure of the meeting with reference to the Treasurer's report?

A motion prevailed to approve the report and place it on file.

PRESIDENT DOAN: It now becomes necessary to provide a nominating committee for the officers of 1938. The Constitution provides that the nominating committee shall be nominated and elected by ballot. We will now entertain such nominations.

PROF. WALTER H. BUCHER: I wish to offer the motion that the Vice-Presidents of the various sections this year act as the nominating committee for the coming year and that the Secretary be authorized to cast such a ballot.

This motion was duly seconded, put and carried.

MR. ALEXANDER: Mr. President, I take pleasure in casting a written ballot for the following persons: C. F. Boord, Fred Foreman, Reuel B. Frost, Clarance H. Kennedy, Ralph A. Knouff, Garry C. Myers, G. E. Owen, Claude E. O'Neal.

PRESIDENT DOAN: Under unfinished business is an amendment to the Constitution and By-laws to be acted upon at this time.

MR. ALEXANDER: At the last annual meeting of the Academy notice was given that an amendment would be offered. The Secretary was asked to prepare an amendment in line with the suggestions made at that time: We suggest the following: To Article IV add a new section to be numbered 4a to read as follows, viz.:

> 4a. *Membership Committee*—The Membership Committee shall consist of one member from each Section of the Academy, elected by the Section or appointed by the Vice-President of the Section, and shall seek to secure new members for the Academy, pass upon the sufficiency of applications and make report with recommendation to the Executive Committee or the Academy.

PRESIDENT DOAN: As required by the Constitution, this amendment has been announced and laid on the table for a year. It is now up for final action of the Academy if it so wishes. Are there any comments or recommendations with reference to what final action on this amendment to the Constitution should be taken? What is your pleasure?

Motion prevailed to incorporate the proposed amendment into the Constitution.

PRESIDENT DOAN: It shall be so ordered. As you know, last year the incoming president was authorized by the Academy to appoint a committee to take under advisement the proper observance of the semi-centennial of the founding of this Academy, which would occur three years hence. So at the beginning of my administration I appointed Secretary Alexander, Professor F. C. Waite, Prof. Herbert Osborn, Prof. Walter H. Bucher, and Prof. Wm. Lloyd Evans. Mr. Alexander as chairman has his preliminary report to make at this time.

MR. ALEXANDER: I regret exceedingly that Doctor Waite is not able to be present with us this morning. We fully intended to have him present this report. The report as now read is largely his work and is approved by the entire committee. I wish I could read this report as Dr. Waite could read it. It consists of two parts, namely, the report proper, and an appendix. I shall read the report proper first.

(Mr. Alexander then read the report. Printed elsewhere.)

MR. ALEXANDER: That is the report proper and I think should be acted upon first.

PRESIDENT DOAN: I know this has been given much attention to prepare so comprehensive an outline. I am sure you and I appreciate the work of this committee for the plan of an event three years in advance. It seems to me a vote of acceptance and commendation is certainly in order. Are there any suggestions or questions to the committee from the floor you would like to make at this time. You know it is proper to make them in writing at any time. Mr. Alexander is chairman of the committee, so any recommendations to him with reference to this matter, I am sure, will be entertained most cordially by this committee. Will you accept the preliminary action of the committee?

Motion prevailed to accept the report of the committee.

PRESIDENT DOAN: Shall we hear the rest of the report?

MR. ALEXANDER: Mr. President, in view of the lateness of the hour, the full program ahead of us, and the fact that the second part of this report is simply an appendix to the first part and consists entirely of suggestions to the several committees provided for in the first part, suggestions that they may or may not follow, may I suggest the advisability of omitting the reading of the second part; simply accept it and place it on file. It also has the approval of the entire committee.

PRESIDENT DOAN: As long as the report of the committee in its fullness is on file, perhaps that will be accepted and inasmuch as the Academy has approved your outline in detail, I think the machinery has been put in motion to carry on in the fashion outlined.

I would like to say at this time to the officers and executive committee, the custom of postponing the decision of the place of meeting has been followed for a number of years. We have considered the possibility of deciding during one annual meeting the place of meeting for the next annual meeting. Therefore, I would like to say at this time we will entertain during this morning session invitations from any institution that would like to be considered for a meeting place next year. The Executive Committee is meeting at 1:00 o'clock today, and it is hoped that a decision will be reached at that time and the announcement made at the banquet tonight as to the place of the meeting for next year. I am simply making this announcement now so you can think about it and see Mr. Alexander at the close of the meeting and inform him of the desire of your groups. Apropos of this suggestion, there have been one or two invitations already received, which will be mentioned at the end of this morning's meeting. I thought perhaps some of you would like to be considering this during the morning and see Mr. Alexander in person with reference to this matter.

The hour set for the general scientific session of the Academy having arrived, I will, with your approval, declare the business meeting of the Academy in recess until after the scientific program.

THE GENERAL SCIENTIFIC SESSION

PRESIDENT DOAN, *Presiding*

PRESIDENT DOAN: The officers of the program committee found that we have been particularly fortunate in the provision of variety in our program which is prepared for this morning. We have been interested in the individuals and the work to be presented from a general scientific standpoint for some time, so we are delighted to have a resume and climax by those who have consented and have accepted very generously the invitation of the Academy to come and be with us. We have been interested, of course, in the scientific aspects of Polar explorations. We found that we have in one of our Ohio institutions an active participant in such an expedition, that here was an opportunity that we should not overlook or miss, so we have been very happy and I think very fortunate, to have Professor F. A. Wade, of Miami University, who was a member of the Second Byrd Antarctic Expedition, who will present some of his scientific findings as a part of that memorable and scientific expedition.

(Dr. Wade read his paper, which was illustrated with remarks as the slides were thrown on the screen.)

PRESIDENT DOAN: I have been thrilled with some of the experiences of phenomena with the application of high speed moving picture films, and they are yielding now to the new methods of showing vegetable growth. We have been fortunate in securing the presentation of two films taken by the Massachusetts Institute of Technology to be explained by Prof. Alpheus W. Smith. The pictures were made by Prof. Edgerton, of the Massachusetts Institute of Technology. They are being used to investigate phenomena that would elude ordinary approach. This means the possibility of probing into natural phenomena in a way not possible before. We are making the first approach in this work.

PROF. SMITH: (While slides were being thrown on the screen.) These speed films will have a great utility in the physical and biological phenomena and in scientific research. The research in this direction is not finished. There is almost no limit to the interesting information in the scientific and biological fields that can be secured; so the possibility of working the field out and leaving nothing for succeeding generations is very limited.

PRESIDENT DOAN: I am pleased to announce that beginning this afternoon at 4:15 at University Hall, O. S. U. campus, through the courtesy of Professor Smith, all who so desire may again see some silent motion pictures under the interpretation of other speakers. These films will include the moon, the solar system, the solar family, electrons, volcanoes and electrochemistry. All are invited.

It has given me very real and personal pleasure in anticipation of having Doctor Todd with us today, because ever since he has been in the department of anatomy at Western Reserve University, I have been interested in his work and have followed it very closely. It has been our privilege to work together. Dr. Todd, as you know, is a director of the Hampton Museum, and directs the Health Association of Cleveland. His topic is "Certificates of Growing Up and Growing Old." So it is with very great pleasure that I present Dr. T. Wingate Todd of Western Reserve University.

DOCTOR TODD: I think the selection of my subject has been a little ambitious. I shied at the details of the latter part, so I shall deal more particularly with "growing up." I have tried to be as impersonal as possible in this matter.

(Dr. Todd's lecture was illustrated with slides.)

PRESIDENT DOAN: Thank you very much, Dr. Todd. I feel that we have had a real treat in this scientific program, and I express to each of you who have contributed to this program very deep appreciation and thanks for being with us.

(At the conclusion of Dr. Todd's address the general scientific session was closed and the business session resumed with President Doan presiding.)

PRESIDENT DOAN: We will now proceed with the final matters of business that must come before us at this time. The next in order is the reports of standing committees and we will begin with the report of the Executive Committee by the secretary.

(The report as published elsewhere was then read.)

PRESIDENT DOAN: If there are no objections, the report of the actions of the Executive Committee for the interim between the last meeting of the Academy and this annual meeting will be accepted and filed. I think, perhaps, action is necessary upon one matter that came up during the year. The secretary has called attention to certain correspondence regarding an exchange of honorary memberships between a Swedish organization and the Ohio Academy of Science, as outlined in the report of the secretary. At the same time the work of Dr. McClure, of Canton, China, came up, and the Executive Committee recommends that Professor McClure also be elected to honorary membership in the Academy. The Constitution provides that there be not more than 25 such members. There are at the present time only one or two members in that category, therefore, we are well within the provision of the Constitution should we decide to take this action.

Motion prevailed that the Academy elect as honorary members the four Swedish representatives and Professor McClure of China.

PRESIDENT DOAN: May we have the report of the Publications Committee, Professor Rice, chairman?

PROFESSOR RICE: There is no report to make.

PRESIDENT DOAN: Next is the report of the Research Fund, Dr. Osborn.

DR. HERBERT OSBORN: The report is in the hands of the Secretary.

MR. ALEXANDER: The report is on file and has been audited, but somehow I failed to bring it with me. Sorry.

PRESIDENT DOAN: If there is no objection, I shall rule that it be filed and made a part of the minutes.

PRESIDENT DOAN: Is there any report from the Library Committee?

MRS. ETHEL M. MILLER: I have made this report short this year.

(Mrs. Miller read her report. Printed elsewhere.)

PRESIDENT DOAN: What is your pleasure with reference to this report?

Motion prevailed to receive and file it.

PRESIDENT DOAN: Is there any report from the Committee on State Parks and Conservation?

MR. EDWARD S. THOMAS: Owing to the lateness of the hour, I want to ask that the reading of the report be omitted. However, I have some recommendations I would like to submit.

(Mr. Thomas read the recommendations. Report printed elsewhere.)

President Doan: Is there any comment or discussion of this report of great importance that Mr. Thomas has just made?

Motion prevailed that the report be accepted and that the moral support be put 100% back of it.

President Doan: I hope that measures will be taken to see that this is given full publicity.

Mr. Thomas: I shall endeavor to do this. The name of this Committee should be changed. The words "State Park" is more or less redundant. I would suggest that it be called "A Committee on Conservation" only. It would be much more concise and accurate.

President Doan: We will be glad to take that to the Executive Committee. The next report is that of the Membership Committee.

Mr. Alexander: Speaking for the committee, permit me to say that 39 applications have been received and approved and their election to membership is hereby recommended.

Without reading the names, a motion prevailed that the 39 applicants for membership be elected.

A motion also prevailed that other applications received during the session be treated likewise.

President Doan: Dr. Osburn will report for the Necrology Committee.

(Dr. Osburn read his report. Printed elsewhere.)

President Doan: What will you do with the report?

Motion prevailed that it be received and placed on file.

President Doan: A report from the joint Administrative Board and the Ohio Journal of Science is next in order.

(Prof. E. L. Rice, as Secretary of the Board, read the report. Printed elsewhere.)

President Doan: What is your will?

Motion prevailed that the report be accepted and filed.

President Doan: We will now have Dr. Waller's report on "Save Outdoor Ohio."

Dr. A. E. Waller: This report covers subjects covered by Mr. Thomas, but from another angle. The wildlife sanctuary has been a project of the Ohio Academy of Science for many years.

(Dr. Waller read his report. Report and recommendations printed elsewhere.)

President Doan: What is your wish?

Motion by Dr. Osburn, seconded by Prof. Smith, that the report be accepted and that the Academy go on record as indorsing specifically the recommendations of the Committee, was unanimously carried.

President Doan: We will now receive the report of the Nominating Committee.

(The report was submitted by Prof. Guy-Harold Smith. Printed elsewhere.)

On motion of Prof. Smith, seconded by Prof. Busch, the report was unanimously approved and made a part of the minutes of the Academy.

President Doan: The officers for next year will function as indicated. The next is the report of the Committee on Resolutions.

(Report read by Dr. Walter H. Bucher. Printed elsewhere.)

President Doan: What is your pleasure?

Motion prevailed to accept the report.

President Doan: There are two items of new business, the fixing of the time and the place of the next meeting. As I said at the beginning this morning, it has been thought that it would be wise to have a selection of next year's meeting place made during the present meeting. In the past the Academy has entrusted to the Executive Committee the selection of the place of meeting later in the year. As previously stated, it has been thought well to select the next place of meeting while this meeting is in session. With that in mind, we will entertain invitations, and the place selected by the Executive Committee can be announced later.

Prof. R. V. Bangham invited the Academy to meet with the College of Wooster next year and the secretary read a telegram inviting the Academy to meet at the University of Cincinnati in 1938.

A motion prevailed that the Executive Committee be entrusted with the selection of next meeting place and that it be announced at the banquet.

President Doan: We shall attempt to report on this tonight. If there are any other colleges wishing to be considered, give your invitations to Mr. Alexander at the close of the meeting.

Motion was offered authorizing the Executive Committee of the Academy to fix the date of the next meeting between the 1st and the 15th of May.

PRESIDENT DOAN: Rather than holding the meeting early as in the past, it has been thought that better weather would prevail and also that many could drive in on the later date.

PROF. GUY-HAROLD SMITH: I do not have any objection to the spirit of this motion, but I think it is undesirable to limit the Committee to 15 days.

DR. HERBERT OSBORN: I think the motion would tie the hands of the Executive Committee.

PROF. E. L. RICE: I do not think that the hands of the Executive Committee should be tied.

PRESIDENT DOAN: Those in favor of the motion, raise your right hand. The motion is lost. However, I think the spirit is to arrange a meeting date most convenient for all concerned. Do you wish to select a representative on the Council of the A. A. A. S. at this time?

PROFESSOR SMITH: I move that the matter be referred to the Executive Committee.

Motion carried.

MR. ROSCOE W. FRANKS: In the past, it has been customary for the Committee on Nominations to designate the chairman of the Committee on Conservation. This time it was not done.

PROF. G.-H. SMITH: So far as we know there is no reason why we should name the chairman of that group and we left it entirely with that committee to select its own chairman.

PRESIDENT DOAN: The group will select its own chairman. Is there any other business that should come before the Academy at this time? If not, I wish to thank Capital University for their hearty cooperation in arranging for the entertainment of the Academy this year. The experiment in dual sponsorship seems to have worked well. The meeting stands adjourned.

THE SCIENTIFIC SESSIONS

GENERAL AND SECTIONAL

The following is a list of the addresses and papers presented at the general and sectional meetings of the Academy as reported to the secretary, viz.:

1. THE PRESIDENTIAL ADDRESS: Modern Medicine—the Crossroads of the Social and Physical Sciences..............DR. CHARLES A. DOAN
2. *Invitation Address:* Scientific Research in the Antarctic (Illustrated), DR. F. ALTON WADE

3. *Invitation Address:* Certificates of Growing Up and Growing Old (Illustrated)...Dr. T. Wingate Todd
4. *Invitation Address:* Science and Higher Learning...Dr. Otis W. Caldwell
5. *Moving Pictures:* High Speed Moving Pictures of Selected Biological and Physical Phenomena. Made by Professor Edgerton, M. I. T., and presented by Dr. Alpheus W. Smith.
6. The Determination of Small Mammal Populations by the Quadrat Method...B. P. Bole
7. The Effect of Sex Ratio on Fecundity, Fertility and Mortality of the Blowfly (Phormia regina Meig)...A. C. Miller
8. Difference in Response to Meat Between Male and Female Blowfly (*Phormia regina* Meig.)...Herbert Matsumori
9. The Supramarginal Ridge in Certain American Snails...David T. Jones
10. A Short Field Method for Determining Dissolved Oxygen in Water, Lee S. Roach
11. An Ecological Approach to the Identification of Birds of Northwestern Ohio...Irene T. Rorimer
12. Life History and Ecology of Opalina...F. O. Hazard
13. Ohio Fisheries Statistics...E. L. Wickliff
14. Manayunkia, a Freshwater Polychaete from Lake Erie...F. H. Krecker
15. Bubble Nest Activity of *Betta splendens* under Controlled Conditions of Light and Temperature...Virginia Bennington
16. Prenatal Development of the Water Snake, *Natrix sipedon* (L), John W. Price and Milton P. Solomon
17. Notes on the Development of the Central Nervous System of Black Blowfly...Paul E. Schaefer
18. Order of Differentiation of Gamic Female Aphids...Chester A. Lawson
19. Looking for Endoproctous Bryozoa in Bermuda...S. R. Williams
20. Tagging Native Stream Fish...Ralph V. Bangham
21. Transplanted Lateral-line Organs in the Tadpole...Henry Federighi
22. The Animal Population of Aquatic Plants...F. H. Krecker
23. Five Years of Field Observations on the Eastern Chipmunk (*Tamias striatus fisheri* Howell)...Arthur B. Williams
24. Ecology of Ohio Camel-crickets (Orthoptera: Gryllacrididae), Edward S. Thomas
25. The Analysis of Human Inheritance in Data Comparing but a Single Generation...Charles W. Cotterman
26. Facilities for Vertebrate Research in Ohio...Lawrence E. Hicks
27. Progress Report of the American Fish Policy...E. L. Wickliff
28. "Reduced," A New Mutation in *Drosophila Ananassae*, Harrison D. Stalker
29. Methods of Improving Fish in Lakes and Ponds of Ohio...T. H. Langlois
30. Zonal Distribution of Mosses on Mount Rainier...E. T. Bodenberg
31. The Ohio State Moss Herbarium...R. T. Wareham
32. A Lichen Succession on Blackhand Conglomerate Cliffs of Hocking County, Ohio...John N. Wolfe
33. Notes on Ohio Violets and Additions to the State Flora...F. O. Grover
34. Vegetation of Muskingum County, Ohio...Charles A. Dambach
35. Additions to the Revised Catalog of Ohio Vascular Plants, John H. Schaffner
36. Plant Remains Found in a Lignite Deposit of Central Ohio, Robert K. Lampton
37. The Gray Mold Disease of Greenhouse Tomatoes...T. W. Bretz
38. Some Incrusting Forms of Telephora...S. S. Humphrey
39. Basidiomycetes of the Chagrin River District of Northern Ohio, Mrs. Harvey Bingham
40. A Key to the Ohio Apple Disease...W. G. Stover
41. The Rice Industry of South Carolina...A. E. Waller
42. The Ethno-botany of the Ohio Aborigines...H. C. Shetrone
43. Some Physiological Studies in the Thermal Algae of Yellowstone National Park...O. L. Inman
44. Initial Studies in Antibiosis Between Lower Organisms, Const. J. Alexopoulos
45. The Relation of Stump Height to the Sprouting of *Ostrya virginiana*, Oliver D. Diller

46. Copper Solutions for Microscopical Detection of Glucose and Fructose, Elizabeth S. Bretz
47. The Vegetation of Meigs County, Ohio..........Clyde H. Jones
48. Some Micro-organisms from the Olentangy Shale..........Grace A. Stewart
49. Three New Species of Tetraseptate Corals from the Hamilton of New York..........Daniel A. Busch
50. Fauna of the Typical Olentangy Shale..........Clinton R. Stauffer
51. Richmond Dalmanella Bed Invaded by Carnivorous Gastropod, Walter H. Bucher
52. The Overlap Relation of the Chattanooga Shale..........Harry J. Klepser
53. The Hot Springs District of Virginia..........Arthur Bevan
54. Structures in the Pliocene Lavas of McCoy, Eagle and Routt Counties, Colorado..........Henry F. Donner
55. A Generalization of the Structure of Ohio, Indiana, and Michigan, J. R. Lockett
56. The Problem of Silicosis and Other Dust Diseases..........Charles B. Moke
57. Some New Mineral Occurrences in Southwestern Ohio..........John Sarles
58. Level and Flat..........George D. Hubbard
59. Recent Earthquakes in Western Ohio..........John T. Rouse and R. R. Priddy
60. Meteorologic Factors of the 1937 Flood..........Paris B. Stockdale
61. Flood Prevention in the Ohio Valley..........J. J. Wolford
62. Mechanism of Iron Transportation in the Blood Stream: Its Significance in Anemic States of Varied Etiology..........Carl V. Moore
63. The Normal Urinary Excretion of Iodine, Italo D. Puppel and George M. Curtis
64. The Increased Urinary Excretion of Iodine in Hyperthyroidism, George M. Curtis and Italo D. Puppel
65. Ketene as a Detoxifying Agent..........M. J. Boyd
66. Composition of Human Saliva as Affected by Atropine and Pilocarpine Stimulation..........Henry Limbacher and J. B. Brown
67. Chemical and Physiological Properties of Dacryorrhetin...Shiro Tashiro
68. Estimation of Vitamin A Deficiency..........Rollin R. Durant
69. Influence of Cortin on Renal Excretion in the Normal Organism, Frank A. Hartman, Lena Lewis, and Gwendoline Toby
70. Effect of Cortin Injection on the Urinary Ammonia Excretion..Lena Lewis
71. Histological and Chemical Analysis of the Lipids of the Adrenal Cortex of the Guinea Pig in Pregnancy, Fatigue and Starvation, Bernard M. Schneider
72. Effect of Cold and Double Adrenalectomy on Metabolism, Steven Horvath
73. Effect of Adrenal Cortical Extract on the O_2 Consumption of Human Beings..........Fred A. Hitchcock
74. Experimental Studies on Ovulation, A. J. Derbyshire and Hans O. Haterius
75. Human Ovulation..........Kelley Hale
76. Endocrine Functions of the Placenta..........Hans O. Haterius
77. Total Distribution of Taste Buds on the Kitten Tongue at Birth, Rush Elliott
78. Birefringence of Muscle..........Emil Bozler
79. Differential Reaction of Bone Marrow and Lymph Node to Hyperpyrexia, C. A. Doan, Malcolm M. Hargraves and Lucile Kester
80. Propagation of Vaccinia Virus in the Rabbit Fetus, Fred W. Gallagher and Oram C. Woolpert
81. Patent Ductus Arteriosus with Infected Thrombus Simulating Subacute Bacterial Endocarditus...Ray Brown, F. L. Ferguson and T. T. Frost
82. Effects of Posture on Respiration in the Human, J. K. W. Ferguson and Fred A. Hitchcock
83. Comparative Histology of the Reptilian Oesophagus, Lawrence I. Goldberg
84. Effect of Splenectomy of the Rat on the Weight of the Hypophysis, Linden F. Edwards
85. The Nature of the Human Pulmonic Alveolar Wall...Dwight M. Palmer
86. Thyroid-Adrenal-Brain Relationships in Vertebrates..........D. P. Quiring
87. Does Resection of the Nerves of the Mandible Affect Development of the Teeth?..........Paul C. Kitchin and Linden F. Edwards

88. Relationship between Basophilic Infiltration of the Neurohypophysis and Hypertensive Disorders.....Horace B. Davidson and John R. Ross

The next five papers were given as a *Symposium on the Neurone:*

89. The Structure of the Neurone as Revealed by Polarized Light, Hugh Setterfield
90. Metabolism of the Neurone..............................Robert Grubbs
91. Neuro-Hormones....................................Emil Bozler
92. Nature of the Conduction of the Nerve Impulse......Arthur Derbyshire
93. Neurotropic Viruses with Special Reference to Poliomyelitis, N. Paul Hudson

94. Dunlap's Beta Hypothesis Applied to Learning to Spell, Mary K. Valentine
95. Preliminary Report of Results Obtained from a New Type of Maze, Winford L. Sharp
96. Changes in Interest and Social Activities Over a Four-year College Period.. Richard Wilkinson
97. Binocular Interdependence in "Non-Corresponding Point" Stimulation, S. R. Wallace, Jr.
98. An Experiment in College Guidance...............Everett H. Hopkins
99. Functional Indications of Improved Associations in Normal Adults Taking Amino-Acetic Acid..........................Florence Mateer
100. A Hazard in Altitude Testing.......Ralph C. Irwin and H. B. English
101. Needed Research in the Psychology of Music.......Gordon Hendrickson
102. Transfer of Training in Learning to Hit a Submerged Target, William H. Schroeder
103. A Preliminary Report on Time Discrimination in the Chick, Amos C. Anderson
104. An Activity-Project Program of Instruction in Educational Psychology, Harriet M. Hicks
105. Some Factors Which Influence the Determination of Gustatory Thresholds...R. H. Scofield
106. The Scientific Nature of the Case Method............Stanley Marzolf
107. A Study of Speed vs. Accuracy in the Acquisition of Motor Skill, Wilbur D. West
108. Some Relationships of Speed to Other Measures of Ability and Achievement...James P. Porter
109. Zeeman Effect Studies in Neon......................J. A. Peoples, Jr.
110. Intensity Measurements in the Calcium Spectrum............Jack Smith
111. A Search for the Spectrum of Doubly Excited Helium......F. P. Bundy
112. Variate Atom Equipoints and Mixed Crystals in Their Relation to Space-Group Theory....................................F. C. Blake
113. The Absorption Spectra of Pure Chlorophyll *a* and *b* in Ether Solution, H. V. Knorr and V. M. Albers
114. The Absorption Spectrum of Chloroplasts in Living Cells, H. V. Knorr and V. M. Albers
115. Frequency Measurements in the Elementary Laboratory......Will C. Dod
116. Phase Changes in Resonant Circuit, and Effect of Polarized Light on a Photronic Cell.......................................Alva W. Smith
117. The Infra-red Absorption Spectrum of the Deuterium Selenides, William C. Sears
118. Stars with Composite Spectra...............................J. A. Hynek
119. Intensities of Forbidden Lines in the Spectra of Novae, N. T. Bobrovnikoff
120. Improved Apparatus and Techniques for the General Laboratory, Leroy Edwards
121. Making Stresses Visible.................................Royal Weller
122. A Lightning Flash and Its Components.................John G. Albright
123. Cross Hairs.......................................Richard M. Howe
124. An Empirical Equation for Loudness......................H. P. Knauss
125. The Addition of Two Frequencies in Audio Apparatus...Darrell B. Green
126. The Viscosity of Sols Made from X-irradiated Substances, C. Harrison Dwight and H. Kersten
127. Some Political and Trade Barriers to the Division of Labor, Alfred Archer
128. Geography of Civilization and Culture...............George D. Hubbard

129. Significance of the Evolutionary Nature of Georgaphy, Kyle W. Armstrong
130. Notes on the Geographic Philosophy.................Roderick Peattie
131. The Distribution of University and College Teachers of Georgaphy, C. E. Cooper
132. Temperature Influences of Lake Erie................Robert Schloemer
133. A Sketch of the Geographic Evolution of the Fox Wisconsin Portage, John H. Garland
134. The Anthracite Landscape........................Raymond E. Murphy
135. A Reconnaissance Survey of Lynchburg, Va...............James A. Beck
136. Flood Control in the Muskingum Valley.................C. C. Huntington
137. Wadsworth, Ohio—A Detached Fragment of Greater Akron, Evelyn Weston
138. Some Aspects of the Political Geography of the Low Countries, J. O. M. Broek
139. A Simple Gasometer..................................W. C. Ebaugh
140. Efficient Laboratory Distillation...................Philip R. Fehlandt
141. Capital University Chemistry Project No. 5—Assembly for Class Demonstrations of Vacuum Tube Phenomena, K. G. Busch, W. Toor, R. Heischman and R. Thayer
142. Special Student Problem on Soil Analysis—Project No. 4, Grover L. Orr and Lloyd Jessen
143. A New Unit Plan for Individual Instruction in General Chemistry, G. W. H. Powell
144. Experiences Teaching Proficiency Students in Chemistry, W. Conrad Fernelius, Laurence L. Quill and Wm. Lloyd Evans
145. Training Graduate Students as Teachers, Laurence L. Quill, W. Conrad Fernelius and Wm. Lloyd Evans
146. The Methods Course in Chemistry....................M. P. Puterbaugh
147. Synthesis of 1, 2-Benzanthracene Derivatives Related to 3, 4-Benzpyrene...Melvin S. Newman
148. The Newer Approaches to the Study of Biological Significance of the Lipids. 1. Chemical. 2. Cytological..A. W. Bosworth and J. H. Akeroyd
149. A Modified Ferric Alum Solution for Use in the Permanganate Titration of Cuprous Oxide in the Bertrand Sugar Determination and the Substitution of Dichromate for Permanganate for the Titration, E. D. Witman
150. An Experimental Study of Glucose Formation from Fat in the White Rat Using a Modified Respiratory Apparatus.............C. B. Marquand
151. Occurrence of Porphyrins in the Urine in Sulfonal Poisoning, Paul Rothemund
152. Isolation of a Crystalline Vitamin A Concentrate, Ruth E. Corbet and Harry N. Holmes
153. The Use of the Chain Hydrometer in the Preparation of Standard Solutions of Hydrochloric Acid...........R. V. Sinnett and C. W. Foulk
154. Electrometric Indicators and the Dead Stop End-Point System, D. R. Clippinger and C. W. Foulk
155. The Effect of Calgon on the Hardness of Water...........Samuel Shenker
156. Solubility of Mercuric Oxide in Alkali and Alkaline Earth Solutions, Alfred E. Hirschler and Alfred B. Garrett
157. Studies on the Rare Earth Nitrates, Richard F. Robey and Laurence L. Quill
158. Preparation and Properties of Some 1, 2, 3 Triazoles, N. O. Cappel and W. Conrad Fernelius
159. Absorption Spectra of Certain Indigoid and Thioindigoid Dyes, Ronald B. Spacht and W. R. Brode
160. The Synthesis of Olefins of Type IV.—Trialkylethylenes, C. E. Boord and Amos G. Hornby
161. The Dipole Moments of Acid Chlorides; Resonance in Molecules, Sister Mary Mercedes

Report of the Secretary

For the Year 1936-37

COLUMBUS, OHIO, May 14, 1937.

To the Ohio Academy of Science:

The work of the Secretary's office, as in past years, has gone along quite harmoniously through the year now ending, without serious interruption and we believe with reasonable success. We have had the most loyal co-operation possible on the part of the entire official family and we have met with the utmost courtesy and consideration on the part of the membership at large, whose servant we are and whom we serve with gladness. It has been a real joy to serve with President Doan and support in every way possible his efforts to advance the interests of the Academy. We have never known an era of greater enthusiasm and good will in the Academy than now prevails as shown by the large enthusiastic attendance at this meeting.

So many of the details that pass through the Secretary's office and are partly if not wholly taken care of there are covered by or included in the reports of other officers or committees that as a rule only minor matters remain for this office to report.

The Secretary again had the honor, through the courtesy of the Executive Committee, to represent the Academy on the Council of the American Association for the Advancement of Science at the Atlantic City meeting and also at the Academy Conference of which he, for a second time, had the honor to be its president. This Academy Conference is designed to be a sort of clearing house of helpful ideas and information particularly helpful to academy secretaries. To say the least, the inspiration a secretary may gain at one of these conferences is worth the time and cost, as he should be a better secretary thereafter.

By personal conferences with the officials of the Association we succeeded in securing a generous allowance for research among our members, although we had really and technically forfeited our claim by our failure to comply fully with the terms of the grant. The thanks of the Academy are due Dr. Otis W. Caldwell, the distinguished general secretary of the Association, who we hope will honor us with his presence at this meeting. He is our friend.

As chairman of the special or preliminary committee appointed by President Doan to outline a plan for the proper observance of the 50th anniversary of the organization of the Ohio Academy of Science, three years hence, we have given much time and thought to this matter, as have the other members of the committee. We trust the results of our deliberations will commend themselves to you, at least to the extent of being a good beginning, and may point the way to a plan that will make the observance of the semi-centennial of the Ohio Academy of Science an outstanding event in the march of Science not only in Ohio but in the country as a whole. To do this, however, will require the full, hearty, enthusiastic co-operation of every member of the Academy.

We certainly do not arrogate to ourselves as chairman of the program committee any special credit for the fine, rich programs, both general and sectional, prepared for your profit and pleasure, but we may with propriety cite this fact as evidence of the fine spirit of co-operation that prevails in the Academy at this time. We think the vice-presidents have done unusually well.

As mentioned in the report of the Executive Committee, the Academy has made a beginning in the matter of exchange of corresponding, or honorary members, between the Ohio Academy of Science and other organizations, foreign and domestic. This will probably result, let us hope, in the adoption and making of a suitable Academy seal.

Again, hearty thanks, good friends, for your many and repeated expressions of your confidence, the honor of serving you, and your sympathetic co-operation.

Respectfully,
WILLIAM H. ALEXANDER,
Secretary.

Accepted and ordered filed by unanimous vote of the Academy May 14, 1937.

Report of the Auditor

To the Ohio Academy of Science:

Following is the Balance Sheet of the Ohio Academy of Science as at December 31, 1936:

OHIO ACADEMY OF SCIENCE BALANCE SHEET

As at December 31, 1936

ASSETS		
Cash in Bank—Huntington National	$ 185.41	
Bonds	1,300.00	
*Stock—Ohio National Bank (cost)	437.50	
Total Assets		$1,922.91
SURPLUS		
Surplus		$1,922.91

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* In the account of the Research Fund.

STATEMENT OF RECEIPTS AND DISBURSEMENTS

For the Year Ending December 31, 1936

RECEIPTS		
Bank Balance—Huntington National Bank		$ 195.59
Sale of Publications	$ 34.20	
Dues	1,041.30	
		1,075.50
Total Cash		$1,271.09

DISBURSEMENTS

Office Expense	$ 20.00	
Preliminary Announcements	12.88	
Stamps and Stationery	22.16	
Secretarial Services	51.00	
Expenses to Executive Committee	18.15	
Auditing Service	3.00	
Registration Cards	3.87	
Bank Service Charge	8.10	
Vice-President Expenses—Chemistry Section	5.59	
Invitation Speaker	50.00	
Expenses, Toledo Meeting	18.24	
Programs	57.43	
Vice-President Expenses—Botany Section	9.33	
Vice-President Expenses—Physics Section	11.25	
Vice-President Expenses—Psychology Section	14.25	
Expenses—Zoology Section	15.00	
Stenotypist's Service	5.75	
Secretary's *Honorarium*	100.00	
Guest Speaker, Medical Section	35.00	
Ohio Journal of Science (Paid up Membership)	577.50	
Secretarial Services	20.68	
Letterheads	9.86	
Vice-President Expenses—Geology Section	5.50	
Statements	9.64	
Stenographic Service	1.50	
Total Expense		1,085.68
Cash Balance		$ 185.41

I have completed the audit of the books for the Ohio Academy of Science for the year ending December 31, 1936, and have found the following facts to be true:

1. There is $185.41 in cash which is held on deposit with the Huntington National Bank.

2. The $1,300.00 in bonds were verified by the Ohio National Bank.

3. There are $437.50 in stock of the Ohio National Bank, which is valued at cost.

4. The members ledger was checked in detail and was found to be correct as to the amount received.

5. All invoices were checked in detail as to the amounts disbursed.

I certify that the above statements set forth, to the best of my knowledge, the true and correct financial condition of the Ohio Academy of Science as at December 31, 1936.

Respectfully submitted,

BRYAN HARTLEY,
Assistant Fraternity Auditor,
Ohio State University.

Report of the Preliminary Committee on 50th Anniversary of the Ohio Academy of Science

COLUMBUS, OHIO, May 14, 1937.

To the Ohio Academy of Science:

Your Committee appointed by President Doan, pursuant to a motion passed at the Toledo meeting of April, 1936, submits the following report:

We heartily commend the celebration of the semi-centennial of the *Ohio Academy of Science* and believe that this should be done in a distinctive and comprehensive manner that will not only commemorate what has been accomplished in the past fifty years, but will also stimulate yet greater endeavor in the future. We hope that the program will be sufficiently worthy that the proceedings when published will be a real contribution to the literature of science and of scientific organizations.

To this end we make the following recommendations:

1. That the 50th Annual Meeting be held at the Ohio State University in Columbus, the birthplace of the Academy, in 1940, the month and days to be designated later.

2. That the meetings of 1938 and 1939 be held elsewhere than in Columbus.

3. That the 50th meeting be devoted entirely to the semi-centennial celebration, consisting of two major parts, one *historical* and the other *scientific.*

4. That the meeting be organized and carried through by a Director and ten committees.

5. That the Director have general supervision of the entire celebration and be ex-officio a member of each committee.

6. That the Nominating Committee for the 1938 meeting present one or more suggestions for the position of Director and that their suggestion or suggestions for this position be announced at the first business session of the meeting of 1938 and voted on at the final session of that meeting.

7. That the committees be grouped into two groups on the basis of the sequence of their activities.

8. That each committee consist of not more than three members, and that not more than one honorary member may be, but not of necessity must be, added to each committee.

9. That the committees be as follows:

GROUP A

(1) On Publicity, both preliminary and current.
(2) On Program.
(3) On Speakers, including guests.
(4) On Invitations.
(5) On Historical Statistics and Lists.

Group B

(6) On Exhibits.
(7) On Memorials.
(8) On Dinner.
(9) On Finances.
(10) On Publications.

10. That the Executive Committee choose and appoint at least the chairman of each of the five committees in Group A, not later than December 1, 1937, with the expectation that a preliminary report from these five chairman will be presented at the 1938 meeting.

11. That the completion of all committees be accomplished not later than December 1, 1938, and that all committees report either separately or through a general report by the Director at the 1939 meeting.

Respectfully submitted with the understanding that when amended and adopted the carrying out of these recommendations be the duty of the officers and executive committee of the Academy.

W. H. Alexander, *Chairman*,
F. C. Waite,
Herbert Osborn,
Walter H. Bucher,
Wm. Lloyd Evans.

APPENDIX

In the preparation of this report suggestions have been made which may be useful to the committees and same are here recorded, but are not a part of the report of the committee and therefore are in no way mandatory.

A. We believe that great care should be exercised in the selection of the Director and the members of the committees. Choice should be based on willingness and ability to give this service, rather than on any attempt to bestow honors. To care for this feature the honorary members of the committees are suggested.

B. Invariably unmodified consent to serve should precede appointment.

C. Selection of members of each committee with some regard to geographical proximity will permit meetings of committees and promote efficiency.

D. If the chairman of a committee be first chosen and then asked for suggestions as to other members of his committee it will promote the activity of each committee.

E. We suggest that the program be divided into a historical part to occupy approximately three-fourths of the meeting, and a scientific part.

F. The scientific part should consist of three, four or five papers of scientific worth rather than of historical value, in order to stimulate the scientific activity of the society. For these speakers we suggest securing scientists of national repute, each in a different field, to represent the wide interests of the Academy. If men who are natives of Ohio or have been former residents of the State can be secured it will be more appropriate. It is suggested that the scientific program be entirely by visiting speakers, but that papers read by title from members of the Academy may also be carried on the program.

G. In addition we suggest that the representative of the American Association for the Advancement of Science and the designated representatives from each of the academies of the five adjoining states (Michigan, Indiana, Kentucky, West Virginia, Pennsylvania) be asked to take a minor part in the program, such as brief remarks, at the dinner.

H. To the committee on exhibits, we suggest an exhibition of scientific apparatus used fifty years ago and now, and a limited exhibition of text-books used fifty years ago and now, possibly arranged according to fields covered with perhaps some scientific exhibits that are distinctly Ohioan, such as fossils or type specimens, and scientific books by Ohio authors.

I. To the Committee on Historical Statistics and Lists, we suggest that tabular statements, supplemented perhaps by charted graphs, be used as far as possible, showing, among other things, the number of papers presented during the last fifty years, divided into fields of work, the total number of individuals who have had places on the programs, a complete list of all general officers with a short biographical sketch of the presidents, such as in American Men of Science, and possibly a complete list of all who have been members of the Academy during the past fifty years. It may be possible to assemble a synopsis of contributions to science in Ohio before the Academy was founded, with a list of leading writers and papers and scientific organizations within the State. Possibly an addition of pictures of early Ohio scientists and a list of outstanding scientists who have been born in Ohio or educated in Ohio, or did scientific work in Ohio. This might be cared for by a paper on the program entitled "Science in Ohio before 1890."

J. To the Committee on Memorials, we suggest the possibility of building up by solicitation of the capital of the *Research Fund*, same to be placed in the Irreducible Debt Fund of the State of Ohio, the law permitting; also the erection in a place to be selected of a bronze tablet, possibly the gift of some friend of the Academy.

K. To the Committee on Publications, we suggest as a primary aim the preparation of a volume or record suitable for wide distribution which should contain, of course, an account of the semi-centennial, perhaps most of the statistical summaries regarding the Academy, but should not attempt generalised historical sketches on the progress of science, but should be confined, rather, to local (Ohio) scientific history, especially of accounts of incidents and anecdotes which illuminate the mind and circumstances of a given period, since future generations will look upon the mere factual contents of local history as secondary to these. The older members of the Academy who know the facts owe it to the coming generation to put these human documents into the record before they vanish from the field.

L. To the Finance Committee, we suggest a small registration fee and solicitation of special gifts to be used chiefly in defraying the traveling expenses of the principal invited speakers.

Respectfully submitted, with request that the committee be discharged.

W. H. ALEXANDER, *Chairman*,
WALTER H. BUCHER,
F. C. WAITE,
HERBERT OSBORN,
WM. LLOYD EVANS.

Report of the Executive Committee

COLUMBUS, OHIO, May 14, 1937.

To the Ohio Academy of Science:

The meetings of the Executive Committee during the year have been timely, well attended and characterized by the free, frank and intelligent discussion of all matters pertaining to the good of the Academy. Details were promptly taken care of. Only a few matters were of such nature as to require the action of the Academy or of sufficient importance to merit the attention of the Academy. The following, however, do seem to require such action:

1. Early in the year there came to the President of the Academy and by him referred to the Committee a proposal from Dr. Fredericks Son on behalf of a Swedish organization (apparently genealogical in character) to enter into "an exchange of corresponding members between our respective Societies in order to promote a more intimate collaboration between U. S. A. and Sweden." The proposal, in brief, is for the Swedish organization to "immatriculate" three members of the Ohio Academy of Science as honorary members and for the Ohio Academy to immatriculate three of its members into the Ohio Academy, without dues in both cases. Dr. Fredericks Son suggested the following names: (1) Henric-Leonardsson Westman, (2) Dr. Adelbert Fredericks Son and (3) Dr. Georg-Georgsson Akerman. The committee looked with favor upon the proposal and authorized the President to nominate three persons for membership in the Swedish organization, whereupon he suggested the following names: William H. Alexander, Frank A. Livingston and Dr. Laurence H. Snyder. Dr. Fredericks Son courteously insisted upon adding the name of our President, Dr. Charles A. Doan. The committee now submits the matter to you for your approval or disapproval.

Relative to honorary memberships in the Academy, the Executive Committee put itself definitely on record as of the opinion that these do not entitle such members to the free receipt of the *Ohio Journal of Science* since it seems reasonable to assume that said members will have access to the Journal at a near-by institution that is already on the exchange list of the Academy.

Further, it may be said, incidentally, that the final approval of this exchange of members would seem to require the adoption of a suitable academy seal to be attached to the certificates of membership issued to these alien organizations. To this end, action has already been initiated looking to the securing of such a seal. The fact is your committee feels that the Academy should have a seal for other purposes.

2. The committee approved a proposed amendment to the Constitution and By-Laws prepared by the secretary making the committee on membership permanent. Its approval by the Academy is hereby recommended.

3. Two vacancies occurring during the year in the list of vice-presidents were filled by the committee, namely, Dr. C. F. Boord was made vice-president of the Section of Chemistry, vice Dr. A. P. Mathews, declined, and Dr. Clarence H. Kennedy was made vice-president of the Section of Zoology, vice Dr. A. W. Lindsey, resigned.

4. The committee recommends the election of Dr. F. A. McClure, now professor of botany at Lingnan University, Canton, China, to honorary membership in the Academy.

Respectfully submitted,

WILLIAM H. ALEXANDER,
Secretary.

Report accepted and placed on file by unanimous vote of the Academy with the understanding all recommendations made therein are approved.

Report of the Library Committee

COLUMBUS, OHIO, May 14, 1937.

To the Ohio Academy of Science:

More requests than usual have been received this past year for missing numbers of the *Ohio Journal of Science.* Such numbers are usually sent, depending upon the supply in stock. All such requests were granted this year except in a few instances where entire sets of the *Ohio Naturalist* and the *Ohio Journal of Science* were wanted. Some gaps in the sets of the periodicals which are received in the Ohio State University Library have been filled in by the organizations which exchange with the Ohio Academy of Science.

One exchange was resumed which had ceased at the time of the war. Our publications had been sent before the war, but somehow none had been received in return. Hence nothing was known about this exchange until a letter came this winter asking that the exchange of publications be resumed. This Society has sent a shipment consisting of ninety-nine volumes of its publication covering the years from 1904 on to date and it has offered to send the volumes from 1889 to 1903 inclusive if they should be desired. The shipment which has been sent has not yet been received. In return a shipment has been sent from here which contained all the numbers of the *Ohio Naturalist* and of the *Ohio Journal of Science* which were lacking from the library of this Society.

Four new exchanges were secured during the year and eight were dropped as publication of their journals had been discontinued. When it is resumed these exchanges can likely be secured again if desired. The total number of exchanges is now 372, of which 104 are in this country and 268 in foreign countries.

The sales of publications amounted to $37.10. Fourteen sales were made and seventy-six items were sold, consisting of thirty-six Special Papers and forty Annual Reports. "The Odonata of Ohio," by D. S. Kellicott, and the "Flora of the Oak Openings West of Toledo," E. L. Moseley, were in greatest demand.

In order to avoid any possible difficulty with the Tax Commission of Ohio it seemed wise to secure a vendor's license. This was done October 1, 1936. So far only two sales have required the tax stamps. However, it is a satisfaction to know that the law is not being violated.

At the close of the fiscal year the only outstanding bill was the one for 1935 which was reported last year. It has since been paid.

The sum of $31.07 is still on deposit in the building and loan company. This sum represents only the dividends which were earned by the money from sales when deposits were made in former years. No money has been deposited for five years, but instead it has been paid directly to the Treasurer each year. The dividends have amounted to $35.82, but the sum of $4.75 was withdrawn at the time when the last of the sales money was taken out and was paid to the Treasurer. The sum now remaining in the bank is earning a trifle over a dollar a year.

Respectfully submitted,

ETHEL MELSHEIMER MILLER,
Chairman.

Report of the Joint Administrative Board of the Ohio Journal of Science

COLUMBUS, OHIO, May 13, 1937.

To the Ohio Academy of Science:

A meeting of the Joint Administrative Board was held at the Bancroft Hotel, Springfield, Ohio, on April 23, 1937. Meeting was called to order by Chairman Rice about 2:00 P. M. All members of the Board, the Editor, and Business Manager were present. All incumbent officers were re-elected for 1937.

Subject to their acceptance Prof. W. H. Shideler, of Miami University, was elected sub-editor for Paleontology, replacing August F. Foerste, deceased, and Prof. H. H. M. Bowman, of the University of Toledo, was elected sub-editor for Botany, replacing Prof. L. H. Tiffany, resigned.

Upon motion it was declared policy of the Journal that cuts would be returned to authors on request with the understanding that the Journal retains the right to their use in the future.

Upon motion it was declared policy of the Journal that permission will be given to quote the Journal upon request, provided permission of the author is granted.

The Business Manager presented his financial report as follows:

OHIO JOURNAL OF SCIENCE
Fiscal Year 1936

Receipts

Balance from 1935	$ 115.73
University Grant	750.00
Ohio Academy of Science	577.50
Ohio Academy of Science, Proceedings	130.40
Subscriptions	77.68
Sales of Back Numbers	36.50
Author's Payments for Plates and Publications out of Order	96.37
	$1,784.18

Expenditures

Spahr & Glenn Co., Vol. 35, No. 6	$ 166.35
Spahr & Glenn Co., Five Numbers of Vol. 36	1,083.43
Bucher Engraving Co	145.44
Postal Charges	97.69
Envelopes and Stationery	37.85
Clerical Assistance	5.00
Bank Charges	.50
	$1,536.26
Balance on hand Feb. 5, 1937 (Huntington National Bank)	247.92
	$1,784.18

The bill for the September, 1936, number of the Journal, amounting to $249.50, is still unpaid. All other 1936 bills are paid.

Motion carried that report be accepted and placed on file.

Dr. Transeau was appointed a committee of one to audit the report.

The meeting adjourned about 3:00 P. M.

Respectfully submitted,

B. S. Meyer,
Secretary.

Report of the Committee on State Parks and Conservation

May 14, 1937.

To the Ohio Academy of Science,

The past year has seen continued activity in a great variety of conservation matters. The establishment of a co-operative wild life research station at Columbus, Soil Conservation activities, sealing of abandoned coal mines, construction of reservoirs for the conservation and control of water, acquisition of forest areas and other important projects have contributed toward another outstanding year in conservation annals.

Soil Conservation.—During the past year the U. S. Soil Conservation Service has continued its important functions in Ohio.

Watershed projects at Zanesville, Wooster, Mt. Vernon, and Hamilton are leading the way, and a new 74,000-acre similar project near Senecaville will soon swing into action. Sixteen CCC camps carry the work forward on other fronts. In co-operation with the Agricultural Extension Service, the Soil Conservation Service is showing farmers how they can control erosion—and adoption of approved soil conservation practices is spreading.

Strip cropping, a method of cultivation in which contour strips of close-growing, soil-binding grasses are alternated with similar bands of clean-tilled crops, is advocated for many slopes. Contour tillage, or plowing across the slopes rather than up-and-down hill, is recommended for most rolling fields. Terracing is demonstrated in a minor degree in certain sections of the state.

Woodlands are receiving more and more recognition as an essential part of the co-ordinated program of erosion control. Land covered by forest provides an excellent example of how nature originally protected the soil. The forest floor is covered with a litter of fallen leaves and twigs and decaying vegetative matter, rich in humus that is sponge-like in its ability to absorb and hold water.

Protecting woodlots by fence, wherever possible, allows underbrush and new trees to obtain sufficient growth. A woodlot thus protected insures against soil erosion and also provides ample food and cover for game birds and other wild life. In general, the steeper slopes are being returned to permanent woodlands. Slopes not quite so steep, yet too steep or too eroded for profitable cultivation, are retired to permanent pasture.

Longer crop rotations are being advocated by the Service, a four-year rotation of corn, wheat, and two years' meadow being the most common type recommended. Liming and fertilizing are an essential part of the program. Gullies are being controlled by vegetation wherever possible, although temporary check dams are sometimes necessary.

Controlling erosion through vegetation will also conserve wild life, soil conservationists point out, since the two needs of wild life that go hand in hand are food and cover, and both are supplied by vegetation. Farm ponds are proving valuable in conserving water for use during intermittent periods of drought, and for control of erosion. They also serve a useful purpose in wild life conservation by furnishing a haven for wild ducks and geese, and, if properly cared for, may often be stocked with fish.

In general, the erosion control program being advanced by the Soil Conservation Service is a general land use program, in which each acre is put to its proper use. In March, 1937, more than 260,000 acres were under co-operative agreement with the Service, and the number is still growing. Moreover, and a heartening sign, thousands of farmers outside of project and camp areas are adopting similar practices on their own initiative. Soil conservation is fast becoming a reality.

Biologists will commend the policy of the Service in making wild life research an important element of the soil conservation program.

Sealing Abandoned Coal Mines.—Since its inception in December, 1934, the mine sealing project has resulted in the closing of more than 19,500 mine openings of various types in Ohio. The work is being actively carried on in 22 counties, giving employment to about 750 workmen. To date, about $740,000 of federal funds have been expended on this work including funds supplied by CWA, ERA, and WPA. The average cost of closing each opening is about $39.90. It was originally estimated that there were about 25,000 openings to abandoned mines in this state. To this number must be added about 5,000 openings in mines abandoned during the last three years. At the present time about 1,000 openings are being closed per month. Hence it will require about one year to complete the work.

The work already completed has resulted in a considerable reduction in the amount of acid and iron discharged to the streams of Ohio in drainage from abandoned mines. Reductions of from 50% to 75% in the acidity of mine drainage in one year's time after sealing are not uncommon. Frequently reductions of two or more tons of acid per day in the drainage from one large mine are brought about by the mine sealing program. Already streams in the coal mining area of Ohio are showing marked improvement.

While the funds for this work are provided by the federal government as a part of its work relief program, the technical supervision of the project is under the direction of engineers of the U. S. Public Health Service and the Ohio Department of Health. After the federal program is completed, it will be necessary to enact legislation requiring that the openings to mines now active be sealed when abandoned. In order to obtain the fullest benefit from the work it is necessary that the seals be maintained in air-tight condition and that cave-ins be closed as soon as they occur. Responsibility for this maintenance work may rest with the individual mine or property owner.

Division of Conservation.—During the past year an important program was established as regards research on wild life matters. Through a co-operative arrangement between the Ohio State University and the Ohio Division of Conservation, the Franz Theodore Stone Laboratory at Put-in-Bay, which has hitherto operated for three months of the year, will now function as a fisheries research institute, as well as in an academic capacity and will be open throughout the year. Dr. D. M. DeLong, of the Ohio State University, is Director and Dr. T. H. Langlois, of the Ohio Division of Conservation, is Assistant Director.

Research and Administration.—The research activities of the Ohio Division of Conservation were separated from the administrative work. Research is now centralized at Ohio State University, Franz Theodore Stone Laboratory and the Ohio State Museum. The administrative and promotion headquarters are located on the eleventh floor of the Ohio Departments Building.

Fish and game management work were added to the functions of the Division of Conservation.

In 1930 the Ohio Division of Conservation started a program of limnological investigations of its ponds, lakes and reservoirs primarily to determine their suitability for natural propagation, and for stocking hatchery fingerlings and Lake Erie breeder fish.

To date the Division has made preliminary investigations of 57 bodies of water in 50 counties. The card file shows 979 ponds, lakes and reservoirs in 86 of the 88 counties. Of this number approximately 90 per cent are impounded. The impounded waters investigated ranged in size from less than one acre to 16,420 acres and in age from one month to 100 years. Between 500 and 1,000 determinations for temperature, turbidity, oxygen, CO_2 and pH have been made, and a similar number of samples of phytoplankton, zooplankton and bottom organisms identified, counted and tabulated.

The card files and stream maps show 358 old dams out of existence and 388 dams now present. Such old sites are potential places for new dams. The Division's large stream maps show the size of each stream, type of bottom and extent of pollution. Preliminary investigations were made of 19 low dam reservoirs in eight streams and monthly samples are obtained from eight stations in Blacklick Creek. Up to the present time in this stream six dams are completed and one is under construction. At the close of 1936, 110 low dams had been constructed and 15 are now under construction in the state.

Training of Men for Fisheries Work.—The following topic from the Progress Report of the American Fish Policy should be of interest to the Ohio Academy of Science:

"The importance of having well trained men available for fisheries work cannot be over-emphasized The facilities for training in this field are inadequate to meet the present varied requirements. The many divisions and subdivisions of the field and the specific requirements of each must be fully recognized. There must be practical fish culturists and investigators of fish cultural problems, and among the latter some will wish training in the special fields of fish pathology, nutrition, breeding, statistical analysis and fish cultural mechanics.

"We must provide for practical managers of public waters in the interests of sportsmen, commercial fishermen and the broader conservationists and there are plenty of problems here that will require the attention of specially trained investigators.

"The training of professional aquiculturists becomes the responsibility of the colleges and universities.

"Fish culture, aquiculture or limnology covers a broad field. It would therefore appear to be most satisfactory if certain definite aspects of the work were emphasized at each recognized university. As examples of this the University of Wisconsin has developed the physico-chemical and plankton work; Michigan, stream and lake improvement; Toronto, life history and rate of growth of fish; Cornell, stream survey, insect and fish relations and hatchery practice. It is essential that each university deal with all aspects of the general principles underlying aquiculture, and it is just as essential that certain universities accept the responsibility of conducting research with respect to definite problems."

Ohio Wildlife Research Station.—The Ohio Wildlife Research Station is now in its second year of existence. This is a research organization maintained co-operatively by the Ohio State University, the Ohio Division of Conservation, and the United States Biological Survey. The main offices are located on the Ohio State University campus but much of the work is decentralized at eight substations located at strategic positions in each biological unit of the state. Eight men are now engaged in full time work and a number of students in part time work in connection with the development of a broad conservation program for all wildlife species (both plant and animal). Fourteen major research investigations are now in progress.

The chief objectives are:

1. Basic fact finding necessary for the conservation and development of the wildlife resources of Ohio—*which are worth fifty million dollars per year.*
2. Training of skilled personnel competent to wisely administer these valuable resources.
3. Demonstration and education projects leading to proper appreciation, management and utilization of these resources.

As a part of this new work a preparatory undergraduate curriculum in basic plant and animal sciences and a graduate program for students leading to Master's and Doctor's degrees in Wildlife Conservation Management, are now available at O. S. U. A limited number of fellowships are granted which aid in financing part of these graduate investigations.

The wildlife conservation field involves an integrating of all of the basic botanical and zoological sciences through the ecological approach and the proper land use viewpoints. This conservation and utilization of living organisms is closely knit with out-of-door recreational developments, such as state parks, and, as a conspicuous part of the natural resources, is inseparable from soil and water conservation.

Conservation work phases in progress or completed to date are as follows:

1. Some 35 releases on completed phases of conservation research-education work have been prepared and distributed.
2. Major research problems in progress involve the following species: Hungarian Partridge, Pheasant, Fox Squirrel, Grey Squirrel, Deer, Ruffed Grouse, Cottontail Rabbit, Raccoon, the Ohio breeding species of waterfowl and indirectly nearly all Ohio land vertebrates.
3. A "Manual of Ohio Wildlife Resources" is in preparation which will give qualitative and quantitative information on all wildlife groups found in the state.
4. A number of demonstration wildlife management units of township size have been set up in northwestern Ohio where effectiveness of various "production" and "harvest" techniques are being tested, including exploration of the field of proper adjustment of farmer-sportsmen relationships.
5. A Wildlife-Recreational-Land Use Study of 52,000 acres of state owned forest lands in the unglaciated hills of southern Ohio is now in its third year.

6. Cooperative development with the Ohio Agricultural Extension Service of extension techniques in wildlife management with an extension education program reaching all rural groups, especially 4-H Clubs.
7. The largest library in Ohio on all fields relating to wildlife conservation has been assembled at the Station. Its facilities are now available to the people of the state in addition to assistance and advice on biological-conservation problems. Several thousand pages of technical and educational publications and releases are distributed each month.
8. A cooperative investigation of Ohio wildlife diseases has been initiated in Ohio with three full time and several additional part time investigators cooperating.
9. Ohio initiated a progressive step in 1936 which is already being duplicated in several other states. A series of Conservation Schools were conducted by the Research Station staff. The 175 "graduates" of these schools are now teaching or practicing the new and progressive conservation technique introduced. From these new and progressive conservation technique introduced. From those graduates the Ohio Division of Conservation has selected a nucleus of college trained conservation technicians to develop its new Wildlife Management Division.
10. Research is now being completed on the relationship of stream-bottoms and streamside border areas of woody plants to wildlife conservation (both fish and land forms), recreation and soil and water conservation. The key importance of these areas is now being recognized. The Ohio Division of Conservation is now engaged in extensive management of these areas including the construction of large numbers of small dams and the obtaining of many miles of easements of streamside strips, which makes these watercourses available for public-conservation use.
11. Special significant research problems now partially completed include population studies of Ohio vertebrates, development of techniques of measuring animal populations and techniques of Conservation education. In connection with this last, a "Primer of Wildlife Management for Ohio" has been prepared and Wildlife Management exhibits created which have already been viewed by more than one hundred thousand residents of the state. More than 60 lectures and several radio lectures on various phases of wildlife conservation have been given during the past year.
12. Seven research stations similar to the one in Ohio are located on a regional basis throughout the United States. For the first time in conservation history, machinery has now been set up through the research stations which brings into close cooperation the large state universities, the state Conservation Departments, and the federal agencies such as the U. S. Biological Survey. For the first time we are utilizing the best man-power and facilities of each in a broad conservation program based on facts, not opinions, but involving the most careful application of scientific data and ecological principles, in modifying the land use program in

the direction of the conservation of our treasured wildlife resources.

Wildlife Research in Southern Ohio.—Major fields of research now include: wildlife land-use, including forestry-wildlife relationships, ecology and management of the gray squirrel, ecology and management of the ruffed grouse, and ecology and management of the white-tailed deer in Ohio. These studies will be combined with others and will be incorporated in a comprehensive report entitled "The Development and Utilization of the Wildlife Resources of the Unglaciated Appalachian Plateau, with special reference to state-owned lands in Scioto County, Ohio."

Continued development of refuges and sanctuaries on state lands in Scioto, Pike and Ross counties. Sanctuaries and refuges in Scioto county now total 10. There are two in Pike county and two in Ross county in addition. Six of these areas are permanent inviolate wildlife sanctuaries. Two are undergoing management at present, one intensively. Two other sanctuaries in Pike and Ross counties were set aside for intensive management, but permission has not yet been given by the Forestry Division, for the initiation of the necessary work.

Odell Creek Sanctuary has been set aside as an example of intensive wildlife management, and numerous demonstrations such as food patches, wildlife plantings, clearings in heavy timber, log check dams, enlargement of waterholes and deer licks, erection of bird houses, and many other features, inaugurated. Nine food patches involving fourteen acres were prepared this spring, and will be planted to corn, lespedeza, alfalfa, rape, sorghum, and later to rye for winter deer feed. Eight acres will be planted to corn.

Five thousand feet of clearings 100 feet wide were made through the dense forested slopes. These are used as study areas, and effects of forest removal on various wildlife species are noted. Complete ecological studies of the whole biotic community are being consummated on cleared, cultivated, and burned areas.

Release cutting to favor better growth and nut production in various species of trees and shrubs, particularly the Hickories, has been started and it is hoped that man power to finish more of this work will be provided by the Division of Conservation, WPA, CCC or other agencies in the near future.

A complete study of the agricultural and forestry practices in vogue in Scioto county at present is being made. This includes effects of burning on brushlands and broom-sedge meadows and relation to wildlife, effects of late plowing, roadside mowing, kinds of crops grown, interspersion of vegetation types, forest stand improvement, protection of forests against fire, plantings of conifers in large blocks, selective cutting of timber, etc., etc. Wildlife habitats of western Scioto county are being mapped after the method used by Saunders in "Ecology of Birds of Quaker Run Valley," with modifications.

A small nursery in which wildlife food and cover plants are being propagated was begun in 1936. At present there are 3000 norway spruce seedlings, 600 black and honey locust, and about 1000 bird-cherry seedlings on hand. Thirty beds four feet wide and 84 feet long make up the nursery. Maintenance of the nursery has been carried on by a man furnished by the Conservation Division. Approximately 35 species of plants are being propagated here, and there will be at least 10,000 or 20,000 seedlings on hand by autumn, 1937, if weather conditions are favorable.

The value to wildlife of old apple trees still remaining on the Preserve and Forests has been recognized, and many of these trees have been pruned (without destroying nesting cavities of bluebirds, etc.) in order to increase fruit production. These trees are valuable to deer, grouse, rabbits, bluebird, crested flycatcher and other forms of wildlife.

Bluebird Boxes.—Your chairman was instrumental during the past year in carrying out an interesting little experiment looking toward the restoration of our bluebird population in the visinity of Columbus.

With the continued dwindling of our woodlots, the passing of the old rail fences, and finally, the replacing of wooden fence posts with concrete and steel posts, the bluebirds have steadily decreased in numbers. Since these birds feed largely on cutworms, grasshoppers and other destructive insects, they are valuable assets to the agriculturist, while their esthetic value to the community is unquestioned.

By a cooperative arrangement between the Columbus Audubon Society and the Ohio State Museum 100 substantial bird boxes were constructed and erected in the vicinity of Columbus. The results exceeded our fondest hopes. The great majority of the boxes were occupied by bluebirds and the great majority of these successfully raised one or more broods of young. The experiment indicates that our bluebird population can easily be restored in many places by providing suitable nesting sites.

New Conservation Organizations.—Your committee notes during the year the formation of two organizations which are potential forces for the good of conservation. The League of Ohio Nature Clubs is composed of 22 nature societies of various kinds in every quarter of the State. The Natural Resources Council is a national organization in which any group interested in any aspect of conservation is eligible to membership. It is composed of county councils, which elect representatives to a state council, which in turn selects representatives to the national council.

Recommendations.—Your committee approves of the objects and the activities of the Save Outdoor Ohio Council and of the participation of the Ohio Academy of Science in it.

Your committee notes with satisfaction an apparent reduction in activity of organizations in various parts of the state in pest hunts and "vermin killing campaigns." We reiterate our firm conviction that organized pest hunts are uneconomic and contrary to the principles of conservation. Such campaigns are objectionable, first, because they encourage the carrying of firearms during the closed season by undisciplined, often irresponsible persons, making enforcement of our game laws difficult or impossible. Secondly, each pest hunter makes himself a judge of what constitutes a "pest." The economic status of our wildlife is a matter requiring the most exhaustive and careful research. Scientists are well aware of the complexity of the question but few pest hunters have the remotest idea of the problems involved. Pest hunts invariably result in the destruction of many species beneficial to mankind and of many song birds and other animals which are protected by law.

Your committee deprecates the widespread use of miscellaneous poisons by Federal, State and private agencies in efforts to reduce the numbers of certain wild animals.

There is ample biological evidence that the maintenance of a normal mammal population, in relation to its environment, in natural balance, is conducive to the economic benefit of mankind.

The programs of soil conservation, flood control and range improvement, among others, would seem to require for their successful consummation the maintenance, in the problem areas, of a normal native mammal population.

There has been in recent years an enormous expansion in the volume of poison distributed in the United States to control mammals, primarily because of the availability of the personnel of the CCC as distribution agents; therefore your committee recommends and asks that:

1. The practice of poisoning native wild mammals by Federal and State agencies be discontinued except where thickly settled communities may be demonstrated to be in danger of a plague epidemic affecting the mammal population of the area.
2. That private agencies be discouraged in the use of poison as a control medium and that the practice of control by such agencies be limited to areas which are under cultivation, including a reasonable but limited buffer zone.
3. That Federal and State agencies be urged to initiate comprehensive research programs to determine all obtainable facts concerning the relationship of the rodents and predatory animals to the soil, vegetation and the use of the land by man.

Your committee recommends to the consideration of the universities of the state the establishment of a curriculum for the training of men in fish culture, fisheries management and fisheries biology.

Your committee recommends that adequate protection be provided for the sanctuary areas in Scioto County.

Your committee recommends that suitable legislation be initiated and enacted to prevent the devastation caused by strip mining.

We continue urgently to recommend the acquisition by the state of relict communities which are threatened with destruction, and refer particularly to those unique areas, the arbor vitae bog in Champaign County and the oak openings west of Toledo.

Respectfully submitted,

Herbert Osborn,
Wilber E. Stout,
G. W. Conrey,
E. L. Wickliff,
Arthur T. Evans,
L. E. Hicks,
Edmund Secrest,
Emery R. Hayhurst,
Edward S. Thomas, *Chairman.*

Report of the Save Outdoor Ohio Council

COLUMBUS, OHIO, May 14, 1937.

To the Ohio Academy of Science:

A year ago it was possible to report that the Save Outdoor Ohio Council had made progress in co-ordinating efforts in the many aspects of wild life conservation and applying some of these to public instruction. This work is bearing fruit in several lines. This year activity has centered around our State Parks. Briefly we have in Ohio three types of State Parks—Memorial or Historical Parks, Recreational Parks, and Scenic Parks. For some time a question has been in the minds of the Save Outdoor Ohio Council concerning the methods by which these parks might become in part self-supporting. I need not go into details about examples of well run recreational parks in other states, nor the conspicuous success of a privately owned park, the Blue Hole at Castalia Springs. The committee, among whom were our State Forester, Mr. Edmund Secrest, the Director of the Archaeological Museum, Mr. Henry Shetrone, the President of the Sportsmen's League, Mr. Tudor Wilson, the Conservation Commissioner, Mr. Earl Wooddell, Captain Maury, of the Hotels association, Mr. Walton Bliss, of the Ohio Education Association, Mr. Roscoe Franks, of the Save Outdoor Ohio Council, Mr. Walter Tucker, representing the Garden Clubs and the Press and a representative of the Ohio Academy of Science, met with the Finance Committee of the Legislature. The result was an appropriation for a swimming pool near Fort Hill and the understanding that income derived from one park would be applicable to others. It may be possible to see tangible results of this rather shortly. It is hoped that if the way might be made clear that the parks would become self-supporting, that additional purchases would be made of natural sites that could not otherwise be saved from extinction. Two places that should be specifically mentioned are Cedar Swamp, near Urbana, and Fern Lake, in Geauga County. Even if these two purchases do not materialize, there are definite benefits from the idea of unification of our State Parks into a general system. For example, if the State Finance Committee can see the possibility of some income, they might be moved to add a tract of forest land of 660 acres near Fort Hill. This would give the state its first forest sanctuary in that part of Ohio. For it should be remembered that under the existing laws the only direct purchase of sites by the forestry department are tracts of land in which the average price does not exceed five dollars per acre. The areas of the state with fertile soils are excluded from purchase. Under a unification plan sections of a park could be administered from different objectives. The Fort Hill Memorial at the top of a hill will not be interfered with by those who come to the park for the recreation of swimming. A forest area could belong to the park, if the funds became available from the park, and that forest remain a wild life sanctuary.

It is the purpose of this report to show you that your interest and support of the Save Outdoor Ohio Council has helped to make it an effective liason organization. We should not overlook the fact that this Council's beginnings were largely the outgrowth of the enthusiasm of one public spirited citizen, Mrs. George MacDonald, of Wyoming, Ohio.

If the Academy is favorable, I should like to propose that it endorse two activities:

(1) A nominal admission to certain State Parks.

(2) The purchase of the Cedar Swamp and Fern Lake areas.

Respectfully submitted,
A. E. Waller,
Representative of the Academy on the Council.

Report of the Committee on the Election of Fellows

Columbus, Ohio, May 14, 1937.

To the Ohio Academy of Science:

The Committee on the Election of Fellows met last evening at the Deshler-Wallick Hotel, Columbus, Ohio, and elected the following persons to fellowship in the Ohio Academy of Science, viz.:

E. T. Bodenberg
Ralph Orlando Freeland
Charles Clifford Huntington
Birely J. Landis
Thomas Huxley Langlois
Horatio C. Mason
Floyd A. McClure
Louis A. Pappenhagen
Edward Waldo Emerson Schear
John L. Rich
Ralph George Schott
Edward S. Thomas
Bruce K. Wiseman

Respectfully,
Wm. H. Alexander,
Secretary.

Report of the Trustees of the Research Fund

Columbus, Ohio, May 14, 1937.

To the Ohio Academy of Science:

There has been little change in the research fund during the past year, but one grant of $75.00 to Prof. J. P. Porter, of Ohio University, has been made. The statement for the fiscal year ending December 31st, 1936, as submitted for audit is as follows:

Receipts	
Balance on Hand December 31, 1935	$185.77
Received from Interest and Dividends	66.75
Total	$252.52
Disbursements	
By Grant for Research Project—J. P. Porter	$ 75.00
Service Charges, Ohio National Bank	.50
Balance on Hand—Checking Account, Ohio National Bank	177.02
Total	$252.52

There have been no changes in the invested funds during the year.

Bonds at Face	$1,300.00
Stock, Ohio National Bank, at Cost	437.50
Total Invested	$1,737.50
Balance in Checking Account, Ohio National Bank	177.02
Total Resources	$1,914.52

The trustees will be glad to receive requests for grants at an early date as it will facilitate the allotment of funds for the current year.

Respectfully submitted,
Herbert Osborn,
George D. Hubbard,
Wm. Lloyd Evans,
Trustees.

Report of the Membership Committee

May 14, 1937.

To the Ohio Academy of Science:

We, your Committee on Membership, recommend the election of the following persons, whose nominations are in due form and whose dues for one year have been paid, to membership in the Ohio Academy of Science, viz.:

Baker, R. C., (D), Ohio State University, Columbus.
Bennington, Neville, (A), 1114 North Bever, Wooster.
Bingham, Mrs. Harvey C., (B), Bentleyville Rd., Chagrin Falls.
Boord, Dr. Cecil E., (H), Chemistry Department, O. S. U., Columbus.
Bosworth, Alfred W., (D), 381 W. Tenth Ave., Columbus.
Boyd, Milford John, (D), 2347 Fairview Ave., Cincinnati.
Bridgman, Catherine M. (B), R. F. D. No. 1, Ellsworth.
Carlson, Fred A., (G), 171 Oakland Park Ave., Columbus.
Cooper, John R., (C), Mount Union College, Alliance.
Dakan, E. L., (A), Ohio State University, Columbus.
Dickerman, E. Eugene, (B and A), State Normal, Bowling Green.
Federighi, Henry, (Biology), Antioch College, Yellow Springs.
Gebhart, James W., (A), 4926 Donald Ave., South Euclid.
Glenny, Fred H., (B), 1148 Linden Ave., Akron.
Grove, Bert E., (C), 8045 Vernon Ave., Chicago, Ill.
Hamilton, M. J. (C and A), 1753 Kensington Ave., Youngstown.
Hudson, Dr. N. Paul, (D), Ohio State University, Columbus.
Joseph, Sister Mary, S.N.D., (Biol. and Chem.), Notre Dame College, South Euclid.
Kitchin, Dr. Paul C., (D), College of Dentistry, O. S. U., Columbus.
Leedy, Daniel L., (A), Ohio State University, Columbus.
Lewis, Annette L., (E), 356 Cliffside Drive, Columbus.
Miller, Freeman D., (F), 308 N. Pearl St., Granville.
Moore, Carl V., (D and H), 1290 Primrose Pl., Columbus.
Palmer, Dwight M., (D), Dept. of Anatomy, O. S. U., Columbus.
Puterbaugh, M. P., (?), Ashland College, Ashland.
Quill, Laurence L., (H, F, and C), Dept. of Chemistry, O. S. U., Columbus.
Rockwood, Ruth C., (G), La Grange.
Rouse, John T., (C), Orton Hall, O. S. U., Columbus.
Shellhaas, Mark A., (A), 241 N. Main St., West Milton.
Sudlow, Paul L. (B and A), Rio Grande College, Rio Grande.

Toomex, Dr. John A., (D), City Hospital, Cleveland.
Tucker, Walter A., (B), 728 S. Remington Rd., Columbus.
Urban, Sister Mary, O. P. (B, A, and H), St. Mary of the Springs, Columbus.
Venard, Carl, (A), Ohio State University, Columbus.
Wallace, S. R., Jr., (E), 404 University Hall, Columbus.
Wilson, Mrs. James Watson, (Biol.), Muskingum College, New Concord.
Winter, A. R., (Biol.), Ohio State University, Columbus.
Wiseman, Dr. Bruce K., (D), Kinsman Hall, O. S. U., Columbus.
Yates, Paul B., (D), Dept. of Anatomy, O. S. U., Columbus.

Respectfully submitted,

K. G. A. Busch, *Chairman*,
Eugene Van Cleef,
Samuel Allen.

Report of the Nominating Committee

For President	Charles G. Shatzer
For Vice-Presidents—	
A. Zoology	Warren Spencer
B. Botany	Raymond A. Dobbins
C. Geology	John L. Rich
D. Medical Sciences	Bruce K. Wiseman
E. Psychology	Harold E. Burtt
F. Physics and Astronomy	Dayton C. Miller
G. Geography	Frank J. Wright
H. Chemistry	W. Conrad Fernelius
For Secretary	William H. Alexander
For Treasurer	Eugene Van Cleef
For Executive Committee	Charles A. Doan A. W. Lindsey
For Trustee, Research Fund	James P. Porter
For Administrative Board	Edward L. Rice
For Publications Committee	Edward L. Rice F. C. Dockeray Grace Ann Stewart
For Library Committee	L. B. Walton
For Committee on Conservation	F. H. Krecker Edward S. Thomas W. E. Stout
For Representative on Save Outdoor Ohio Council	A. E. Waller

Respectfully submitted,

Guy-Harold Smith, *Chairman*,
D. F. Miller,
Glenn W. Blaydes,
Grace A. Stewart,
Charles A. Doan,
James R. Patrick,
K. G. Busch,

Report of the Committee on Necrology

COLUMBUS, OHIO, May 14, 1937.

To the Ohio Academy of Science:

The Academy has suffered the loss of three active and valuable members during the past year—Dr. August Frederick Foerste, Prof. Jesse Earl Hyde, and Dr. Richard Collins Lord. To this list there must be added also the name of Mr. George P. Harmount, who died in April, 1935. Following are records of work of these members.

Respectfully submitted,
E. N. TRANSEAU,
RAYMOND C. OSBURN, *Chairman,*
Committee.

AUGUST FREDERICK FOERSTE, born at Dayton, Ohio, May 7, 1862. Denison University A. B., 1887; Harvard University Ph. D., 1890; student at Heidelberg and Paris, 1890–1892; awarded an honorary D. Sc. by Denison, 1927. Died April 23, 1937. Dr. Feorste spent nearly all of his life in Ohio and was a teacher in the Steele High School at Dayton from 1893 until he retired in 1932. After his retirement he was associated with the U. S. National Museum, carrying on his studies on the Ordovician and Silurian fossils. He was an excellent all-round naturalist and a splendid teacher. He was one of the early members of the Ohio Academy of Science, elected a member in 1898 and advanced to fellowship in 1920. He was a very regular attendant and contributor at the meetings of the Academy.

JESSE EARL HYDE, born at Rushville, Ohio, May 2, 1884, died July 3, 1936. He graduated at Ohio State University in 1906, specializing in Geology and pursued further studies at Harvard and Columbia Universities. He was Assistant Professor of Geology in Queens University, Kingston, Ontario, from 1911 to 1915, when he was called to Western Reserve University. He was also connected with the Cleveland Museum of Natural History as Curator of Geology from 1922 until 1931, when he was compelled to drop the latter connection because of the condition of his health. He spent many summers in research for the Ohio Geological Survey. He was especially interested in the Devonian fishes of the Cleveland shales, and the Cleveland Museum possesses a remarkable collection as the result of Prof. Hyde's efforts. He was a man of unusual energy and a very strong sense of duty. He became a member of the Ohio Academy in 1905, while still an undergraduate and was elected to fellowship in 1920.

RICHARD COLLINS LORD, born January 4, 1882, at Covington, Kentucky. He was a graduate of Washington and Lee University in 1901, Ph. D. in 1904. He was interested in Chemistry and Geology and did excellent work in both fields. From 1904 until 1922, he was engaged in commercial chemistry. In 1922 he was appointed Assistant Professor of Chemistry at Kenyon College and in 1928 was made Professor of Geology, which position he held until the time of his death, November 1, 1936. Professor Lord became a member of the Ohio Academy of Sciences in 1925.

George P. Harmount. The Committee has been able to obtain but very little information concerning Mr. Harmount. He was graduated from Ohio State University in 1911, with the degree of Bachelor of Education and received the Master's degree in 1912. He was a teacher in the Columbus schools and in 1915 became a member of the Academy of Sciences, with his interests in Geology and Archaeology.

Report of the Committee on Resolutions

Columbus, Ohio, May 14, 1937.

To the Ohio Academy of Science:

Resolution No. 1

Whereas, The Finance Committee of the Legislature has appropriated the sum of $47,500 for the purpose of constructing swimming pools and other recreational facilities in a few State Parks; and

Whereas, It seems desirable that State Parks provided with such special recreational facilities be made at least partially self-supporting, thereby liberating funds for the purchase of additional lands to be set aside as State Parks;

Be it Resolved, That the Ohio Academy of Science recommends the charging of a nominal admission to such State Parks.

Resolution No. 2

Whereas, Funds will become available for the purchase of additional State Parks, if the plan recommended in the first resolution is adopted; and

Whereas, Certain areas in the State now facing extinction need preservation more urgently than others:

Be it Resolved, That the Ohio Academy of Science recommends the early purchase of the following two sites, viz.:

(1) Cedar Swamp, near Urbana, Ohio.

(2) Fern Lake Area, Geauga County, Ohio.

Respectfully submitted by the Resolutions Committee,

H. H. M. Bowman, *Chairman,*
Walter H. Bucher.

PRESIDENTIAL ADDRESS*

MODERN MEDICINE—THE CROSSROADS OF THE SOCIAL AND THE PHYSICAL SCIENCES

CHARLES AUSTIN DOAN, B. S., M. D., F. A. C. P.

In acknowledging the honor you have done the Section on Medical Sciences in permitting one of its members to serve as your President during the past year, may I say first of all that we interpret your action as a recognition of the emergence of medical practice from an ancient and honorable Art into a modern, dynamic Science of Health. Disease has existed on the earth as long as organic life has been known. The archeologist, the geologist, the anthropologist, the explorer, have all contributed affirmative evidence of this belief. The earliest interpretable record dates back some four and a half million years according to the accepted geological calculation of time, and represents a form of parasitism—fossil snails in the act of feeding on crinoids, a species of sea lily. From that time on, as the fossil remains of the earth's earliest inhabitants unfold the story of life before the advent of man, there appears mute evidence of disease as revealed by skeletal abnormalities—fractures, carious teeth, bone necroses—in the now extinct fishes and reptiles. The tsetse fly, today's deadly carrier of cattle plague and African sleeping sickness, has been identified in fossil formations dating back a million and a half years.

Man's arrival on the scene seems to have been greeted by the same onslaught of disease that met the various forms of plant and animal life which preceded him. The "Java man," placed by anthropologists as the precursor of the human race with an estimated age of 500,000 years, shows pathological exotoses of the femur. The "Piltdown man," with an estimated age of 100,000 years and considered the oldest human skeleton yet discovered, has an acromegalic skull. The "Neanderthal man," spanning 75,000 years of elapsed time, has suggested rickets to some anthropologists.

The history and scientific beginnings of medicine extend back to the ancient Egyptians of the very first civilization of which we have written record, some thirty centuries before the rise of the better known Hippocratic school at Cos in Greece. The Smith Surgical Papyrus and the Ebers Medical Papyrus, ancient hieroglyphic records of the diagnosis and treatment of disease as practiced some 3500 years B. C., carry recognizable descriptions of many diseases prevalent in the modern day world. The observations of the beloved late Prof. Elliott Smith, who by 1930 had examined the remains of some 30,000 ancient Egyptians and Nubians representing every period of the last 60 centuries, and the microscopic studies by the late Marc Armand Ruffer of carefully restored and sectioned mummified tissues, each independently bear direct testimony to the diversity and similarity of human pathologic processes, then and now.

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Thus, from time immemorial man has dreamed and speculated and philosophized about the nature and the significance of life, and has shuddered and shrunk and fled from famine and war and pestilence. This amazing world in each succeeding epoch has presented an ever increasing variety of problems, which have challenged the best minds of each age. At the very extreme of complexity, and the last to be satisfactorily approached for solution on a rational scientific basis have been the problems of human health and disease. The true physician has ever stood at the crossroads, receiving the slowly and painfully accumulated facts from any and every scientific source, and has then appropriated, reinterpreted and applied them in the alleviation of human misery and suffering. As a result, like the shedding of a chrysalis, the basis for health was transformed at the turn of the century from a speculative, descriptive, cumbersome classification *of* disease to an exact experimental science for the accumulation of verifiable facts *about* disease. Today, we are seeing the natural result of this metamorphosis in method and technic, derived from the basic natural sciences, in a transfer of the major emphasis in medicine from empiricism to mechanism—from the "cure" of disease to the "prevention" of disease. One by one superstitions based upon error, or upon incomplete knowledge, are giving way to more exact methods of procedure, until we may envisage the composite, Ideal Physician of the future as embodying an appreciation and a working knowledge of all of the intricacies of fact deriving from the social as well as from the physical sciences.

If there is any lesson which we of this era should have learned from the past it is the basic necessity for co-operative effort. If the common problems which civilized man faces today are to be solved successfully, the co-operative intelligence of many minds, wherever existing, irrespective of race, color, creed or narrow sectarian viewpoint, must be focused sharply upon them. Peace—progress—our very existence are seriously threatened through failure to fully appreciate the universality of this fundamental principle—applied economically, socially and politically, as well as scientifically. Medical leadership in recent years has perhaps recognized this challenge more clearly, and realized its *sine qua non* for survival more fully, than many in other walks of life. Epidemic disease is no respecter of geographic and racial boundaries, or of economic, political and social differences, and medical science has had to look to and embrace the intellects capable of solving its problems wherever they have appeared on the face of the earth. Moreover, medical leaders everywhere co-operate in an international health cordon for the dissemination and application of this knowledge, as it becomes available. With transportation and intercommunication in the world today, such that a yellow fever carrying mosquito in an airplane wing on the west coast of Africa this morning, may tomorrow be either in continental Europe or South America, and mayhap the next day on our own eastern seaboard, one cannot evade the reality of the imminence of invasion by disease, even though there be some difference of opinion as to the immediate significance of such feats, with reference to other more obvious forms of invasion.

We may agree, perhaps, then that one of the most important functions being subserved by medical science in the present day is its exemplification of the necessity for, and its demonstration of the ways and means of organization and administration toward, co-operative effort *within* the nation and *between* nations. I need only cite the White House Conference on Child Health and Protection during President Hoover's administration, which resulted in the pooling and critical analysis of our scant information in this basic field and the defining of objectives, which since have been methodically and intelligently and co-operatively pursued; *or* the activities during the past decade under the Research Committee of the National Tuberculosis Association, which has integrated and correlated the research programs in some fourteen Universities, three research institutes and two large pharmaceutical firms, directed toward the better understanding and control, by treatment and prevention, of this great white plague; *or* the diversified activities and integrating functions of the National Research Council and the A. A. A. S., of which this Ohio Academy of Science is a worthy satelite, for the cross fertilization of scientific ideas in the broadest sense; *or* the nation-wide programs for venereal disease and cancer control which are being inaugurated at the present time in this country after the successful mass application of present medical knowledge to these identical problems of disease in Britain and the Scandinavian countries; *or* the American, British, and League of Nations co-operating committees on the study and control of chronic arthritis, representing a group of crippling, painful, and economically hazardous diseases, which are increasingly challenging the health and happiness of civilized peoples; *or* the first international conference on fever therapy held in New York City last month with official representatives from the Ministries of Health of 16 countries; *or* the International Physiological Congress meeting in Boston two years ago, and the International Association of Geographic Pathology meeting in Stockholm this summer with "anemia" as it affects different people in different parts of the world, the topic for discussion for the entire meeting; *or*, finally, the International Health Board under the Rockefeller Foundation, which through the years has led in the encouragement of the development and exchange of men and ideas in matters relating to world health problems.

It may not be too late to hope, or too egotistical or remote for scientific groups, such as this Academy represents, to believe, that many, if not all, of our present seemingly insurmountable economic and social problems would yield more readily and happily to human ingenuity and intelligence, if our leaders and their respective followers were alike endowed with a larger share of their rightful heritage of normal mental and physical health. To that end all such gatherings as the present one contribute more or less directly, and when and if, and not until, the ideal integration of a genetically sound psyche with an optimum somatic and environmental background has been accomplished, will the essential keystone to the arch of human relationships have been provided. "The promise of things hoped for, the essence of things yet unseen," implied in the present material accomplishments of the human race, are alluring to contemplate but impossible to fully prophesy.

The experience of the past half century, during which the spectacular acquisition and practical utilization of knowledge appertaining to the basic organization and reactions of matter has been paralleled by an equally active exploration of the form, composition and functions of living cells and organisms, provides an increasing number of instances in which the two approaches have interacted to the mutual advantage of each. Studies of the applicability of x-rays to the problems of medicine were begun within a few months after the announcement of their discovery by the physicist Roentgen. Radium and radioactive substances have likewise been appropriated by physicians as rapidly as isolated and concentrated in needles and bombs for therapeutic purposes. Deuterium had hardly been isolated by Urey and confirmed by Johnson and other chemists until its biological significance was being explored, even before all of its chemical properties were known. The high frequency, short wave radio field was no sooner found to be the source of discomfort to men working within its immediate vicinity because of the production of fever and malaise, than Whitney of the General Electric Company recognized its potential therapeutic significance and at once enlisted the aid of physicians and bacteriologists and placed the resources of his laboratories at their disposal in the development of this approach to fever therapy. Kettering of the General Motors Research Laboratories followed promptly, designating himself a technical collaborator with the medical investigators in applying modern engineering methods to developing and adapting new apparatus for experimentation and therapy. Last week a headline in the *New York Times*, reporting the meetings of the American Physical Society read: "Progress is made in 'taming' neutron." The next subheading in capital letters only a little less prominent, read: "Physicists are told of Columbia work bringing nearer a powerful aid for Medicine." The x-ray, the gamma rays of radium, the high frequency current and now the cyclotron. The physicist, the electrical engineer and the physician have formed a liason in which each is mutually dependent upon the other. Just as the biologist has been directing the chemist as to which fractions were biologically "active" or physiologically significant—and therefore most important to analyze and synthesize in terms of human health, so the comparative value of the different physical agents developed in the physical laboratories is being appraised and evaluated by the medical investigator as rapidly as evolved. The artificial induction of therapeutic fever by various physical means was inevitable after von Jauregg observed in his Vienna Sanatarium that general paralysis of the insane frequently improved following an intercurrent febrile infection; and, *then*, had the courage of his convictions, sufficiently, to induce fever reactions by inoculating selected patients under his care with the malaria plasmodium. Keenness of observation was thus followed by inductive reasoning, the test of therapy was successfully applied, and, finally, the bacteriological, cellular and humoral mechanisms by which improvement is accomplished are just now becoming clear. It is of peculiar interest and significance that the first effective treatment for syphilis of the central nervous system was dependent upon the introduction of another disease, malaria, which through the years, until Ross, McCallum, et al. discovered its cause and control, had been one of man's worst enemies, and still is in some parts of the world. The ingenuity of the physician is exemplified at its best in such an instance, where in discovering how to conquer one disease, he learned enough to make it his servant in conquering still another scourge of mankind. With the demonstration of the thermolability of the treponema pallidum and of the gonococcus at human fever temperatures the importance of fever *per se* in these diseases has been emphasized and the development of physical means for the induction of fever followed naturally and inevitably.

Another example of shrewd inductive reasoning based upon keen observation by a prepared medical mind occurred during the world war. Baer, an orthopedic surgeon with the American Expeditionary Forces, noted that injured soldiers evacuated some hours after severe injury and with wounds teeming with fly larvae, were less frequently found in profound shock and seemed to have a less stormy convalescence, then men with similar but uninfested wounds. After a decade of pondering this observed fact, during which time children with infected and crippling bone lesions returned to him constantly with recurrences and metastatic disseminations despite the most careful application of modern medical and surgical measures, *he* developed the courage of *his* convictions. Soliciting the aid of David Miller and other zoologists with an intimate knowledge of the life cycle of the maggot, methods for the reproduction of fly larvae under sterile precautions were developed. In the beginning, some enzyme or chemically active secretion was hypothesized as the active principle; and, now, allantoin has been identified by the chemists as the effective substance and is replacing the original less esthetic maggot treatment of mother Nature and the observant surgeon.

Whipple, while studying the comparative value of different foods in the regeneration of hemoglobin in dogs following hemorrhage, discovered that liver was invariably most effective. Minot and Murphy, knowing of these experiments, then, observed that liver fed in sufficient quantities to human patients with pernicious anemia resulted in a prompt and sustained remission. Chemists promptly fractionated liver, and many other tissues, with the eventual isolation of the active erythrocyte maturation principle in a purified and simplified solution suitable for parenteral administration, thus saving the lives of many sufferers from this disease who would rather have died than eat a pound of liver daily for the remainder of their lives. Only later came the keen analysis of Castle, which firmly established pernicious anemia as a deficiency disease dependent upon the exhaustion of an essential hormone in the stomach, and demonstrated that the erythrocyte maturation factor stored in the liver, normally, is the resultant of the interaction of the gastric hormone known as the "intrinsic factor" with an essential dietary or "extrinsic factor" contained in animal protein.

One of the great modern advances in the science of medicine has been the realization that all disease is not necessarily the result of some external circumstance or bacterial invasion, and that there is a distinction between "optimum" health and "apparent" health, i. e., between good, better and best. Vitamine and endocrine researches in recent years have done most to exemplify the potential threat to health and well being of deficiency in these vital elements. The chemist and the physician here combine their resources again in the fundamental problems which underlie the deficiency states. Night blindness, ophthalmia, pyorrhea alveolaris and urinary calculi suggest vitamin A insufficiency. Polyneuritis follows a vitamin B-1 deficiency, and pellagra with dermatitis, pigmentation of the skin, glossitis, stomatitis and at times mental disturbances may be symptomatic of vitamin B-2 complex deficiency. Easy bruising, oozing of the gums or unexplained oedema may reflect a vitamin C inadequacy, and rickets and dental caries have largely disappeared where adequate vitamin D is available in the body economy. A lack of calcium may lead to hyperirritability of the neuro-muscular mechanism, tetany. A deficiency in iron leads to hypochromic anemia, and, if iodine is not available, the thyroid gland suffers. In this connection it is important to remember that interference with *absorption* or *utilization* of essential specific principles may be quite as significant in producing symptoms as their absence from the diet.

Also a new principle in disease has been recognized very recently through the increasing knowledge of the interdependence and interaction of vital physiologic functions between widely separated and apparently unrelated organs. If the function of one is impaired the normal function of the other may lead to premature or untimely invalidism or death. As examples, may be cited the removal of the normal thyroid gland to recompensate the damaged heart—or the elimination of the spleen in selected instances where it acts to inhibit or make less effective the production of blood cells by the bone marrow.

One of the most fascinating fields for speculation and further investigation at the present moment lies with the ultramicroscopic viruses. Since the original demonstration of the infectious properties of filter passing sera from which neither aerobic nor anaerobic bacteria could be cultivated, the question of the ultimate nature of these agents has been warmly debated. Do they represent minute living and propagating protoplasmic bodies or are they more nearly comparable to chemical hormones or enzymes? Within the past few months Stanley, Plant Pathologist at the Rockefeller Institute, Princeton, has reported the isolation, purification and chemical crystallization of the agent which produces mosaic disease in the tobacco plant. Thus, the possibility of an entirely new set of biological phenomena related to complex chemical molecules is suggested, and the differential criteria separating animate and inanimate molecular structures are reduced almost to the vanishing point. Many of the workers in this field at the present time while accepting the non-viable nature of tobacco mosaic virus, still believe that other of the viruses may be the earliest and most primitive forms of living matter. Chemistry and biology must therefore, again function together as handmaidens to pathology.

The plant and the animal pathologist often serve as pioneers in exploring territories in which diseases common also to man exist. Laidlaw's investigations of distemper in dogs and his development of an immune vaccine and therapeutic serum, have given fresh impetus and direction to the search for an effective control of the common cold in man. And Shope's study of the swine influenza which appeared in 1918, coincident with the world-wide spread of human influenza, identified a common etiology for the two diseases through common immunologic reactions. Shope found, however, that in swine it required *both* a filterable virus and a bacterium closely similar to, if not identical with, the Pfeiffer or influenza bacillus to cause the disease, a principle similar to one originally postulated by David Smith for lung abscess.

But the devotees of both the social and the natural sciences are facing still another problem of increasing significance and major importance today. Whereas famine and war and pestilence have acted jointly, and frequently coincidently, in the past in the rôle of Lord High Executioner for the race, and mediators of the law of the "survival of the fittest," it is no longer the physical so much as the social and economic forces attendant upon the transition from a slow-tempo agrarian to a high-tempo industrial civilization, which are picking out the constitutionally unfit and eliminating the psychobiologically inferior. The American disease, as Emerson, Bateman and others have designated it, challenges the best effort and skill of the modern physician and social worker. This disease camouflages under numerous and varied symptomatologies, but the common denominator of them all is the highly altered tension under which life is lived today, as contrasted with a few decades ago. The human body is a delicately adjusted, exceedingly complex mechanism with very definite limitations which vary constitutionally from individual to individual. The psyche is more important to its proper functioning than many of the organic processes which have received such careful and detailed study in the past. The central nervous system of man by the very nature of its integrating, governing and association functions reflects this crowning achievement in organic evolution on the earth today. The material creations of this collective brain, nevertheless, are not being "intelligently" directed and mastered and kept servile to objectives and ends, which would be for the best interests of the race as a whole. Annihilation awaits those who either individually or collectively fail to recognize the "handwriting on the wall." The social and natural sciences must together advance even more clearly and definitely into this domain of modern life and, with increasing factual data upon which to base judgments, make certain that a leadership fully conscious of the lurking dangers as well as the potential possibilities directs our destinies.

Claude Bernard, one of the great physiologists of all time, had rare insight into the dominating motivation of those men of science he designated as the Truth Seekers: "Ardent desire for knowledge, and this knowledge really grasped, and yet always flying before them, becomes at once their sole torment and sole happiness. Those who do not know the torment of the unknown cannot have the joy of discovery, which is certainly the liveliest that the mind of man can ever feel. But, by a whim of Nature, the joy of discovery, so sought and hoped for, vanishes as soon as found. It is but a flash, whose gleam discovers for us fresh horizons toward which our insatiate curiosity repairs with still more ardor. Thus, even in science itself, the known loses its attraction, while the unknown is always full of charm." Or as Pascal put it: "We are in search never of things but of the search for things."

The Section of Medical Sciences in the Ohio Academy of Science salutes you, the underlying, fundamental Sciences from which are synthesized new and more effective and essential answers to these problems of individual and community health. We acknowledge gratefully the past contributions upon which medical progress has been built, and solicit a continuing, ever more intimate and productive liason, in the best interests of—let us hope—a *rising* and not a *waning* civilization.

GRANTS IN AID OF RESEARCH

The Ohio Academy of Science has available a limited amount of funds to allot in aid of research projects. Applications for such aid should give a statement of the project, an estimate of expenses, and indication of time involved. Payments on grants may be made on submission of a statement of expenditures incurred and results secured. On publication acknowledgment should be made of source of grant. Address application or enquiries to chairman of Trustees, Research Fund, Herbert Osborn, Ohio State University, Columbus, Ohio.

LEECHES OF SOUTHEASTERN MISSOURI

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The leeches upon which this paper is based were collected from April to November, inclusive, of 1935, and April, May, June and July of 1936, from southeastern Missouri. This area includes the following counties: Perry, Madison, Wayne, Bollinger, Cape Girardeau, Scott, Mississippi, New Madrid, Dunklin, Butler, Stoddard and Pemiscot. The highest altitude, of about 1,500 feet, is in Wayne and Madison Counties. From here to the extreme southeastern part of the state are the lowlands and swampy areas, the altitude being 250 feet or less. On the east is the Mississippi River into which the four rivers and many smaller tributaries empty.

Because of the essential flatness and swampy condition in Scott, Butler, Stoddard, Mississippi, New Madrid, Dunklin and Pemiscot Counties, which constitutes about 60 per cent of the area, this section has been artificially ditched, resulting in numerous streams in addition to the many natural creeks and smaller brooks.

Heretofore, reports on collections of leeches have been limited chiefly to the waters of the northern and northeastern part of the United States, in the Great Lakes Region, and Canada.

The writer identified a total of fifteen species in his collection. This number compares very favorably with the numbers reported in other works and appears to indicate an abundant leech fauna for the section of the state covered in this report.

The leeches were obtained by examining submerged organic debris, the under side of stones, leaves, wood, clam shells, water plants, fish and turtles, and in the mud and ooze on the bottom of the streams and ponds. In one instance, *Haemopis lateralis* was found a few inches below the soil surface in soil which was sufficiently dry to be plowed. However, the presence of this leech in this habitat is not unusual.

The writer found only one record of leeches reported for Missouri. In "The Leeches of the United States National Museum," Moore (1898) reports two species (one specimen of each) from the Current River, Shannon County, viz., *Glossiphonia parasitica* and *Dina*, species undetermined.

In the southeastern Missouri region there are four families represented, the Glossiphonidae, Piscicolidae (Ichthyobdellidae*), Hirudinidae, and Herpobdellidae.

LIST OF LEECHES OF SOUTHEASTERN MISSOURI

Helobdella stagnalis (Linnaeus, 1758) Blanchard, 1896.

The writer found this species in shallow warm water attached to the underside of stones, sticks and water plants. Found in Perry, Madison, Wayne, Bollinger, Cape Girardeau, New Madrid, Dunklin, Butler and Pemiscot Counties. It is widely distributed in the United States having been reported from Woods Hole, Massachusetts, west to Arizona and from Lake Okechobee in Florida north to southern Canada.

Helobdella nepheloidea (Graf, 1899) Moore, 1924.

Taken in Scott and Pemiscot Counties. Not abundant. This species is reported from Wisconsin, Massachusetts, Minnesota, Lake Erie and southern Canada.

Glossiphonia fusca Castle, 1900.

In southeastern Missouri this species is found in reasonable abundance. Previously reported from Illinois, Minnesota, Wisconsin, the Great Lakes and southern Canada.

Glossiphonia complanata (Linnaeus, 1758) Johnson, 1816.

This species was found, though not common, in nine of the twelve counties. Reported common in the Great Lakes, adjacent states, and Massachusetts.

Placobdella† montifera Moore, 1912.

The writer found this species in shallow water in swampy areas in all but two counties. Previously it has been reported from Connecticut, west to Wisconsin, and from southern Canada south to Illinois.

Placobdella pediculata Hemingway, 1908.

The writer took this species on drumfish (*Aplodinotus grunniens*) from Whitewater and Apple Creeks in Cape Girardeau County. Not abundant. It has been reported from Minnesota, Wisconsin and Illinois.

Placobdella parasitica (Say, 1824) Moore, 1901.

Abundant in all the counties. It has been reported from New York west to Arizona and from Tennessee north to Canada.

Placobdella rugosa (Verrill, 1874) Moore, 1901.

This species was found to be common in southeastern Missouri, attached to rocks, wood and turtles. Reported from Connecticut west to Colorado, and from Canada south to Illinois.

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*The family name Ichthyobdellidae in common usage is not available since the name Ichthyobdella for the type genus is regarded as a synonym of Piscicola.

†In view of the fact that authorities on leeches are divided as to the status of the generic name *Placobdella* R. Blanchard 1893, the present writer has continued to use this currently accepted name without any commitment as to the possible validity of the generic name *Haementeria* de Filippi 1849.

Placobdella picta (Verrill, 1872) Moore, 1906.

The writer has found this species well distributed in southeastern Missouri, though not abundant. Reported from Georgian Bay, Lake Erie, northeastern Wisconsin and Connecticut.

Piscicola punctata (Verrill, 1871) Moore, 1912.

Taken from the common carp (*Cyprinus carpio*) and the buffalo fish (*Megastomatobus cyprinella*), to which they were attached, from the Mississippi River at Commerce, Scott County. In the literature, this species, generally known as the fish leech, has been reported taken from the following fish: Log perch (*Percina caprodes*), perch (*Perca flavescens*), wall-eyed pike (*Stizostedion vitreum*), small-mouthed black bass (*Micropterus dolomieu*), rock bass (*Ambloplites rupestris*), common carp (*Cyprinus carpio*), buffalo fish (*Megastomatobus cyprinella*), from Ohio, Lake Erie, Lake Superior, Minnesota, Nova Scotia, Wisconsin, Georgian Bay, Lake Nipigon and Illinois.

Haemopis marmoratis (Say, 1824) Moore, 1901.

The writer found this species in a semi-aquatic environment in Scott, Dunklin, Pemiscot, Butler, Mississippi and New Madrid Counties. Reported from New Jersey west to Kansas, and north to southern Canada.

Haemopis lateralis (Say, 1824) Moore, 1901.

Six specimens were collected in Caney Basin northwest of Oran, Scott County, in soil dry enough to be plowed. Earlier reports list this species from Maine west to Colorado and from Tennessee to Lake Superior.

Herpobdella punctata (Leidy, 1870) Moore, 1901.

In southeastern Missouri this species was found in great abundance, in shallow water concealed under stones, leaves, and submerged logs. Previously reported from New York, Wisconsin, Minnesota, the Great Lakes Region and southern Canada.

Dina microstoma Moore, 1901.

This species was found in Madison, Cape Girardeau, Scott, Mississippi, New Madrid, Dunklin, Butler and Pemiscot Counties, in the ooze on submerged logs and sticks. Not common. Reported from Pennsylvania, Ohio and Illinois.

Dina fervida (Verrill, 1871) Moore, 1901.

The writer found this species in great abundance in southeastern Missouri, on submerged stones and wood in shallow water. Previously reported from Ohio, Illinois, Minnesota, southern Canada, Lake Erie and Lake Superior.

This study was completed at the Franz Theodore Stone Laboratory of Ohio State University at Put-in-Bay, Ohio. The writer wishes to acknowledge his indebtedness to Dr.

Raymond C. Osburn, under whose direction this work was done, for his kind assistance, encouragement, and many valuable suggestions. Dr. John A. Miller, of Ohio State University, was kind enough to check the author's identifications.

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Methods in Plant Physiology

This book will prove useful to all botanists engaged in teaching laboratory plant physiology. It is the most comprehensive volume which has yet appeared on the subject in the English language. The first part, entitled "Laboratory Exercises," is essentially a laboratory course in plant physiology. The order of arrangement of the topics does not appear to be a very logical one, but this is a minor matter in a laboratory guide. One hundred and eighty-two experiments are described covering all phases of the subject. The experiments are for the most part well chosen although the reviewer is puzzled by the complete omission of any exercises dealing with modern concepts of the osmotic quantities of plant cells. The experiments are classified according to their difficulty into three groups—elementary, intermediate, and advanced, a useful pedagogical device. There are numerous citations to text books and original literature.

The second part of the book, entitled "General Methods," is essentially a brief discussion of standard chemical and physical methods used in plant physiological research. Chemical methods are more strongly emphasized than physical methods. More extensive bibliographies would, in the opinion of the reviewer, enhance the value of this part of the book. The last chapter in this section, by Snedecor, deals with the statistical methods used in biology. The writer has been informed by competent statisticians that this is an excellent introduction to the principles of this subject.

The appendix consists of thirty-three tables covering most of the physical and chemical constants of frequent use in plant physiological work.—B. S. Meyer.

Methods in Plant Physiology, by W. E. Loomis and C. A. Shull, (with a chapter on Statistical Methods by G. W. Snedecor). New York, McGraw-Hill Book Co. 1937.

INSECT HOSTS AND NYMPHAL DEVELOPMENT OF PODISUS MACULIVENTRIS SAY AND PERILLUS BIOCULATUS F. (HEMIPTERA, PENTATOMIDAE)

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Two predacious pentatomids found commonly in Ohio, *Podisus maculiventris* Say and *Perillus bioculatus* F., have been observed feeding on various insects and insect stages in the field. It seems probable that many insects are fed upon at times because of the absence of more favorable hosts. Theoretically, a favorable host is one that allows rapid growth and causes little mortality in the predator population supported by it. Presented here are results of attempts to classify a few of the insects fed upon by these two predators, their suitability being measured by the rate of growth and percent of mortality occurring among sets of nymphs reared in the insectary.

Available insects found to be acceptable to nymphs of *Podisus maculiventris* were the Colorado potato beetle (*Leptinotarsa decemlineata* Say), the asparagus beetle (*Crioceris asparagi* L.), the three-lined potato beetle (*Lema trilineata* Oliv.), the Mexican bean beetle (*Epilachna varivestis* Muls.), the fall webworm (*Hyphantria cunea* Dru.), and the diamond-back moth (*Plutella maculipennis* Curt.). Nymphs of *Perillus bioculatus* were reared on the Colorado potato beetle, the asparagus beetle, the three-lined potato beetle, the cabbage looper (*Autographa brassicae* Riley), and the spinach flea beetle (*Disonycha xanthomelaena* Dalm.).

The larvae of two species of host insects were reared on a number of cultivated plants and weeds. Sets of larvae of the same species so reared are considered as having been plant-conditioned according to the kind of plant on which feeding occurred. Plant-conditioned larvae of *Leptinotarsa decemlineata* were reared on potato, tomato, eggplant, ornamental tobacco (*Nicotiana affinis*), matrimony vine (*Solanum dulcamara*), bull nettle (*Solanum carolinense*), and an ornamental, *Solanum atropurpureum*. Plant-conditioned larvae of *Lema trilineata* were reared on jimsonweed (*Datura stramonium*), trumpet flower (*Datura cornucopia*), Chinese lantern flower (*Physalis francheti*), and an ornamental, *Solanum arboreum*.

TECHNIQUE

Predator eggs were collected from the field and from pairs of adults confined in the insectary. Nymphs molting from the phytophagous first instar to the carnivorous second instar were placed in separate small shell vials to which a constant type of food was supplied daily. The size and number of individuals of the hosts placed in each vial were increased as the nymphs grew so that there was an excess of easily available food present at all times.

Podisus maculiventris Say

Eggs of at least three species of hosts fed upon in the larval, the pupal, and occasionally the adult stage do not appear to be acceptable food for the nymphs of this predator. Of 24 second-instar nymphs confined with eggs of *Epilachna varivestis*, all but two died within four days and without feeding. One nymph consumed 12 eggs and another 13 eggs and lived 16 and 18 days, respectively, without having molted. Six second-instar nymphs refused to feed on eggs of *Lema trilineata* and all were dead after five days. Four second-instar nymphs fed slightly on eggs of *Leptinotarsa decemlineata* from potato, three dying in molt after six days, and one individual completing development and emerging as an adult after 18 days of feeding on eggs. In another set nine second-instar nymphs fed slightly on eggs of *L. decemlineata* from *Solanum dulcamara*, eight nymphs dying after 11 days and the last after 23 days.

The rate of development of the predator nymphs appear to correspond to the rate of development of the hosts fed upon. The body fluids of host larvae having a short larval period, as does *Plutella maculipennis*, appear to be more nourishing than larvae of *Leptinotarsa decemlineata*, having a much longer larval period. Nymphs reared on larvae of *Plutella maculipennis*, *Crioceris asparagi*, *Lema trilineata*, and *Leptinotarsa decemlineata* completed development in that order (Table I).

The species or stages of hosts causing the most rapid development of the predator nymphs did not produce the greatest number of adult predators. However, where the rate of nymphal development was relatively slow the mortality occurring among the nymphs was extremely high in most cases (Table I).

The rate of development and the mortality of the nymphs occurring in sets reared on plant-conditioned larvae of *Lepti-*

TABLE I

Length of the four predatory instars and the percent of nymphal mortality of *Podisus maculiventris* Say, reared in the insectary on several different host insects and plant-conditioned insects of the same species.

HOST INSECT	Stage	HOST PLANT	NO. OF NYMPHS	LENGTH OF INSTARS IN DAYS				DAYS 2ND INSTAR TO ADULTS	PERCENT OF MORTALITY
				2nd	3rd	4th	5th		
Lema trilineata	Larval	*Solanum arboreum*	8	3.7	3.0	4.2	9.0	19.9	14.3
Crioceris asparagi	"	Asparagus	6	2.8	4.3	4.3	7.3	18.7	33.3
Leptinotarsa decemlineata	"	Tomato	6	5.3	4.3	5.0	7.8	22.4	33.3
" "	"	Potato	10	5.0	4.1	4.6	7.3	21.0	50.0
Plutella maculipennis	"	Cabbage	4	3.0	3.5	3.5	6.0	16.0	50.0
Leptinotarsa decemlineata	"	Eggplant	8	4.9	3.7	4.3	6.5	19.4	50.0
Epilachna varivestis	"	Beans	54	*	*	*	*	*	56.6
Leptinotarsa decemlineata	"	*Solanum dulcamara*	33	5.1	4.9	5.1	7.5	22.6	69.7
Lema trilineata	"	*Datura cornucopia*	12	3.3	4.6	4.4	8.0	20.3	75.0
Hyphantria cunea	"	Mulberry	14	*	*	*	*	*	78.6
Leptinotarsa decemlineata	Egg	Potato	9	4.0	3.0	4.0	7.0	18.0	88.9
" "	Larval	*Solanum atropurpureum*	9	4.5	4.0	4.5	7.0	20.0	88.9
" "	"	*Solanum carolinense*	28	5.9	5.3	5.8	7.0	24.0	89.3

* Sets of nymphs not run at comparable temperature.

notarsa decemlineata are apparently affected in some instances by toxic substances obtained indirectly from the host plants. Nymphs reared on larvae which fed on *Solanum carolinense* developed more slowly (24 days) and greater numbers died (89.3 percent) than was the case among sets of nymphs reared on other plant-conditioned larvae of the same species (Table I). *Solanum atropurpureum* was extremely toxic to nymphs of *Podisus maculiventris*, but was much less so to nymphs of *Perillus bioculatus* (Table III). Nymphs of *Podisus maculiventris* developed slowly on larvae reared on *Solanum dulcamara* and the nymphal mortality was slightly higher than among sets of nymphs reared on larvae from potato, tomato, and eggplant.

Perillus bioculatus F.

The eggs of *Leptinotarsa decemlineata* constitute a large part of the food of *Perillus bioculatus* when these are available. Twenty-one nymphs reared in the insectary consumed an average of 231.5 eggs during the four predacious instars (Table II).

Eggs of *Lema trilineata* are fed upon in the field but the small size of the eggs and the few individuals to the mass make them of little value in nymphal development. Seven nymphs reared in the insectary on eggs developed more slowly and the adult bugs were much smaller than comparable nymphs reared on larvae of *Lema trilineata.* The average number of eggs consumed during the four predacious instars was 451.7 eggs (Table III).

Nymphs of *Perillus bioculatus* developed more rapidly and there was less mortality when they were reared on larvae of *Lema trilineata* or *Crioceris asparagi* than on larvae of *Leptinotarsa decemlineata* (Table IV). On host-conditioned larvae of *Leptinotarsa decemlineata* the development of the nymphs was most rapid when feeding occurred on larvae reared on *Solanum dulcamara*, and most prolonged on larvae reared on *Solanum carolinense.* As was the case with *Podisus maculiventris*, the greatest amount of nymphal mortality of *Perillus bioculatus* occurred among nymphs feeding on larvae from *Solanum carolinense.*

TABLE II

Length of the four predatory instars of *Perillus bioculatus* and the number of eggs of *Leptinotarsa decemlineata* eaten in the insectary

Nymph No.	Days in 2nd Instar	Eggs Eaten	Days in 3rd Instar	Eggs Eaten	Days in 4th Instar	Eggs Eaten	Days in 5th Instar	Eggs Eaten	Total		
									Days of Development	Eggs Eaten	Sex of Predator
1	3	7	4	18	3	42	6	101	17	168	Female
2	2	9	3	19	4	38	7	137	18	203	Male
3	2	9	3	20	3	36	6	108	16	173	“
4	3	6	2	21	4	48	6	127	17	202	....
5	2	7	3	25	3	35	7	137	18	204	Male
6	2	5	4	25	6	23	7	117	18	170	Female
7	3	7	2	20	3	35	7	133	18	195	“
8	2	5	3	17	3	29	6	98	16	149	Male
9	2	5	4	27	3	40	7	129	18	201	Female
10	2	6	3	34	3	46	6	108	16	194	“
11	2	11	4	19	3	21	6	108	18	159	Male
12	3	9	2	13	3	62	7	192	17	276	“
13	3	7	2	12	3	51	7	208	17	278	“
14	3	7	3	23	2	35	7	182	17	247	“
15	3	7	3	27	2	35	7	253	17	322	Female
16	3	9	2	9	3	56	7	218	17	292	Male
17	3	10	5	24	2	45	8	189	18	268	“
18	4	9	3	34	3	51	7	213	19	307	“
19	3	8	3	22	2	47	7	208	17	285	“
20	4	8	3	15	5	69	6	159	21	251	“
21	3	8	3	16	2	41	7	253	17	318	Female
Average	2.7	7.6	3.0	21.0	3.1	42.1	6.7	160.9	17.5	231.5	

TABLE III

Length of the four predatory instars of *Perillus bioculatus* and the number of eggs of *Lema trilineata* eaten in the insectary

Nymph No.	Days in 2nd Instar	Eggs Eaten	Days in 3rd Instar	Eggs Eaten	Days in 4th Instar	Eggs Eaten	Days in 5th Instar	Eggs Eaten	TOTAL	
									Days of Development	Eggs Eaten
1..........	3	15	4	67	7	129	12	301	26	512
2..........	3	29	5	52	7	115	13	225	28	421
3..........	4	38	5	42	6	163	14	170	29	413
4..........	4	19	5	60	8	166	13	254	30	499
5..........	4	18	4	48	7	152	11	348	26	566
6..........	4	19	4	38	7	145	12	188	27	390
7..........	5	21	5	50	7	176	15	107	32	361
Average.....	3.9	22.7	4.6	51.0	7.0	149.4	12.9	227.6	28.3	451.7

TABLE IV

Length of the four predatory instars and the percent of nymphal mortality of *Perillus bioculatus* Fabr., reared in the insectary on several different host insects and plant-conditioned insects of the same species.

HOST INSECT	STAGE	HOST PLANT	NO. OF NYMPHS	LENGTH OF INSTARS IN DAYS				DAYS 2ND INSTAR TO ADULT	PERCENT OF MORTALITY
				2nd	3rd	4th	5th		
Leptinotarsa decemlineata	Egg	Potato	13	2.9	3.7	3.7	5.3	15.6	30.8
Lema trilineata	Larval	*Datura stramonium*	23	3.7	3.8	3.8	5.8	17.1	34.8
" "	"	*Physalis francheti*	22	4.3	3.1	3.4	6.3	17.1	36.4
Crioceris asparagi	"	Asparagus	19	3.0	4.3	4.0	6.0	17.3	36.8
Lema trilineata	"	*Datura cornucopia*	8	3.5	4.2	4.2	6.2	18.1	37.5
Disonycha xanthomelaena	"	Spinach, beet	7	*	*	*	*	*	42.9
Lema trilineata	"	*Solanum arboreum*	8	4.0	4.7	4.3	6.3	19.3	50.0
Leptinotarsa decemlineata	"	*Solanum atropurpureum*	6	6.0	5.5	4.3	7.0	22.8	50.0
" "	"	*Nicotiana affinis*	23	6.3	4.3	5.6	6.5	22.7	56.5
Lema trilineata	Egg	*Datura stramonium*	18	*	*	*	*	*	61.1
Leptinotarsa decemlineata	Larval	Potato	11	4.2	4.4	3.8	6.5	18.9	63.8
" "	"	Tomato	31	4.1	4.3	4.1	6.9	19.4	67.7
Autographa brassicae	"	Cabbage	10	*	*	*	*	*	70.0
Leptinotarsa decemlineata	*	*Solanum dulcamara*	35	3.5	3.5	4.6	6.8	18.4	74.3
" "	"	Eggplant	28	5.3	5.1	3.8	7.0	21.2	78.6
" "	"	*Solanum carolinense*	22	5.3	4.1	5.3	8.0	22.7	90.9

* Sets of nymphs not run at comparable temperature.

SUMMARY AND CONCLUSIONS

The rate of development and the amount of mortality among sets of nymphs of *Podisus maculiventris* and *Perillus bioculatus* reared on several hosts and under comparable conditions in the insectary appeared to depend upon the kind of food taken. Insect eggs, when acceptable, were most nourishing and were followed in the order of their value by larvae of hosts, depending upon their metabolic rate. Furthermore, hosts of the same species, but reared on different food plants, caused considerable variation in the rate of development and the relative mortality of the predator nymphs. Nymphs died more rapidly when the rate of development was slow. It appears that certain substances transmitted from the plant through the host to the predator caused large numbers of nymphs to die, yet in some cases did not affect the rate of development of those that survived.

Physiology

In achieving certain aims set forth in his preface, Dr. Wiggers has succeeded admirably in illustrating physiological principles by reference to clinical examples, and its converse, the analysis of many clinical conditions on the basis of established experimental observations—an end which is not given every writer to attain. The volume is comprised of ten sections, beginning with the phenomena of muscular contraction and considering, in order, the physiology of the nervous system, blood, respiration, heart and circulation, alimentary tract, water transport, metabolism, endocrine organs and, finally, reproduction. Of these sections, that on the heart and circulation constitutes, in the reviewer's opinion, one of the most splendid ever written. It is gratifying to note the amount of space allotted to the endocrine organs and to reproduction. Here as elsewhere Dr. Wiggers has exercised skillful perspective, particularly with regard to the more controversial points. The bibliographies are well chosen and each chapter is appropriately annotated with leading references. If any adverse criticism were to be advanced it would concern a somewhat ponderous style which appears from time to time in subject matter where it is felt that greater clarity would have been highly desirable. However, the wealth of wisely considered and excellently organized material which comprises this volume more than compensates for what is perhaps a dubious criticism at best.—H. HATERIUS.

Physiology in Health and Disease, by Carl J. Wiggers; 1124 pp., 2d. Ed. Philadelphia, Lea and Febiger, 1937. $9.00.

ADDITIONS TO THE REVISED CATALOG OF OHIO VASCULAR PLANTS, V.[1]

JOHN H. SCHAFFNER

Since the last report on the additions to the Ohio State Herbarium, a great improvement has been made in the storing of both the Ohio plants and the collections of the General Herbarium. New steel cases have been obtained and it thus became possible to arrange the general collection in cases again. Most of this collection had been packed away in boxes ever since the Botany Department moved into the new Botany-Zoology building in the autumn of 1914, because there was no money available to buy herbarium cases.

During the past year several thousand specimens have again been mounted through the help of six students working under N. Y. A. The collection of mosses has been greatly improved and enlarged under the supervision of Mr. Richard T. Wareham, and a large number of specimens have also been added to the general fern collection. Our enthusiastic amateur botanists have contributed their usual large number of specimens. The rare ones and those which give important extensions of geographical range in the state are listed below together with their localities and the collector's names. Species and varieties new to the state list number 19 of which 6 are escapes from cultivation or accidental and 13 indigenous or of unknown origin. Some of the new records extend the known distribution range very decidedly, and raise puzzling questions as to how the plants came to be in the places where they are now growing. Apparently the most interesting of these is *Scirpus saximontanus* Fern. Collected by Bartley and Pontius in Pickaway County, heretofore not known east of the Black Hills and central Nebraska. *Echinodoris cordifolius* (L.) Griseb. and its variety *lanceolatus* (Engelm.) Mack & Bush, from Ross and Pickaway Counties respectively, are also far east of their supposed natural range. A card index showing distribution by counties of each species, represented in the State Herbarium, is being prepared and when all of the present 50,000 specimens have been mapped, the study of the geographic distribution of our Ohio plants will be great facilitated.

10.1. *Lygodium palmatum* (Bern.) Sw. Climbing fern. Isaak Walton League Farm, Waterloo Twp., Athens Co. About 5-6 miles from the Carbondale record. Walter P. Porter and P. S. Wamsley.

19. *Pellaea glabella* Mett. Northern Purple Cliff-brake. Sidney, Shelby Co. Joseph A. Clem.

42a. *Polystichum acrostichoides schweinitzii* (Beck.) Small. Berne Twp., Fairfield Co.; Laurel Twp., Hocking Co. Chas. R. Goslin.

46. *Woodsia obtusa* (Spreng.) Torr. Blunt-lobed Woodsia. Sidney, Shelby Co. Joseph A. Clem.

50. *Azolla caroliniana* Willd. Carolina Azolla. Little Cedar Point Marsh east of Toledo, Lucas Co. John J. Lynch.

55. *Equisetum kansanum* Schaffn. Kansas Scouring-rush. Deer Creek Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius. Three miles north of Clifton, in Clark Co. John H. Schaffner.

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[1] Papers from the Department of Botany, The Ohio State University, No. 390.

71.1. *Abies balsamea* (L.) Mill. Balsam Fir. Escaped into Mitchells Mills Bog, Chardon Twp., Geauga Co. John W. Aldrich.

81.1. *Echinodorus cordifolius* (L.) Griseb. Upright Burhead. Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

81.1a. *Echinodorus cordifolius lanceolatus* (Engelm.) Mack & Bush. Circleville Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

82. *Lophotocarpus calcyinus* (Engelm.) J. G. Smith. Large Lophotocarpus. Ross Co. Floyd Bartley and Leslie L. Pontius.

84. *Sagittaria cuneata* Sheldon. Arum-leaf Arrow-head. High banks along Deer Creek. Deer Creek Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

87.1. *Butomus umbellatus* L. Flowering-rush. Hatchery Bay, South Bass Island, Ottawa Co. L. H. Tiffany.

98. *Potamogeton epihydrus* Raf. Nuttall's Pondweed. Solon Bog. Portage Co. J. W. Aldrich.

101.1. *Potamogeton crispus* L. Curly Pondweed. Russell Twp., Geauga Co. Vernon Gifford.

115. *Nelumbo lutea* (Willd.) Pers. American Water-lotus. Liberty Twp., Ross Co. Leslie L. Pontius and Floyd Bartley.

144.1. *Scirpus georgianus* Harper. Georgia Bulrush. Rock Run, Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

145.2. *Scirpus occidentalis* (Wats.) Chase. Viscid Great Bulrush. Toussaint Marsh, Carroll, Ottawa Co. John J. Lynch.

150.1. *Scirpus saximontanus* Fern. George Hitler's pond, Circleville Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius. Specimen determined by M. L. Fernald.

156. *Eleocharis mutata* (L.) R. & S. Four-angled Spike-rush. Liberty Twp. Jackson Co. Floyd Bartley and Leslie L. Pontius.

167. *Dulichium arundinaceum* (L.) Britt. Dulichium. Buckeye Creek, Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

174. *Cyperus inflexus* Muhl. Awned Cyperus. Pickaway Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

226. *Carex incomperta* Bickn. Prickly Bog Sedge. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

259. *Carex pedunculata* Muhl. Long-stalked Sedge. White's Gulch, Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

261. *Carex eburnea* Boott. Bristle-leaf Sedge. Dry limestone cliff. Brush Twp., Highland Co. Floyd Bartley and Leslie L. Pontius.

284. *Carex gracillima* Schw. Graceful Sedge. Cedar Swamp, Champaign Co. R. B. Gordon.

287. *Carex flexuosa* Muhl. Slender-stained Sedge. Washington Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.

293. *Carex scabrata* Schw. Rough Sedge. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

320. *Carex intumescens* Rudge. Bladder Sedge, Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

333.1. Change name to *Bromus latiglumis* (Shear) Hitchc., and add, Huntington Twp., Gallia Co. Clyde H. Jones.

337. *Melica nitens* Nutt. Tall melic-grass. Highland Co. Floyd Bartley and Leslie L. Pontius.

353. *Uniola latifolia* Mx. Broad-leaf Spike-grass. Huntington Twp., Gallia Co. Clyde H. Jones.

369. *Eragrostis poaeoides* (L.) Beauv. Low Love-grass, Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

371. *Eragrostis pilosa* (L.) Beauv. Tufted Love-grass. Common in sidewalks between bricks. Columbus, Franklin Co. John H. Schaffner.

386. *Trisetum pennsylvanicum* (L.) Beauv. Marsh False-oats. In a bog, Whites Gulch, Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

444a. *Elymus virginicus submuticus* Hook. Empty glumes and lemmas awnless or nearly so. Pickaway Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

457. *Atheropogon curtipendulus* (Mx.) Fourn. Tall Grama-grass. Apparently native, covering a hillside 1 mile southeast of New Moorefield, Clark Co. E. N. Transeau.

483. *Panicum polyanthes* Schultes. Many-flowered Panic-grass. Nile Twp., Scioto Co. F. B. Chapman.

505.2. *Paspalum pubiflorum glabrum* Vasey. Smooth-glumed Paspalum. Liberty Twp., Jackson Co. and Washington Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.

508. *Paspalum setaceum* Mx. Slender Paspalum. Section 20, Hanover Twp., Butler Co. E. E. Good. Berne Twp., Fairfield Co. Chas. R. Goslin.

516. *Sorghastrum nutans* (L.) Nash. Indian-grass. Section 11, Reily Twp., Butler Co. E. E. Good.

526. *Lilium superbum* L. Turk's-cap Lily. Common in a field in Knox Co. Katie M. Roads.

586. *Heteranthera dubia* (Jacq.) MacM. Water-stargrass. Davenport Pond, Pickaway Co. Leslie L. Pontius and Floyd Bartley.

629. *Iris foliosa* Mack. & Bush. Leafy Blue-flag. Salt Creek Twp., Pickaway Co. Ruth Frances Morris.

631. *Iris germanica* L. Common Iris. Escaped along road. Cedarville Twp., Greene Co. John H. Schaffner.

659. *Ibidium beckii* (Lindl.) House. Little Lady's-tresses. Near Clover Hill Bog, N. Bloomfield Twp., Trumbull Co. R E. Shanks.

675. *Hexalectris spicata* (Nutt.) Barnh. Crested Coral-root. Nile Twp., Scioto Co. F. B. Chapman.

700. *Helleborus viridis* L. Green Hellebore. Hocking Twp., Fairfield Co. Chas. R. Goslin.

707. *Delphinium exaltatum* Ait. Tall Larkspur. Deer Creek Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

727. *Thalcitrum revoltum* DC. Waxy Meadow-rue. Friendship, Scioto Co. Julius B. Katz, F. B. Chapman, and R. B. Gordon.

764. *Alyssum alyssoides* L. Yellow Alyssum. Along interurban R. R. track. Urbana Twp., Champaign Co. John H. Schaffner.

774. *Neobeckia aquatica* (Eat.) Britt. Lake Water-cress. Pickaway Twp., Pickaway Co. Leslie L. Pontius and Floyd Bartley.

793. *Cheirinia insconspicua* (Wats.) Britt. Prairie Cheirinia. long interurban R. R. track. Urbana Twp., Champaign Co. John H. Schaffner.

843. *Polanisia graveolens* Raf. Clammy-weed. Many plants in waste ground. Columbus, Franklin Co. John H. Schaffner. Fairport Harbor, Lake Co. Very common. F. J. Tyler. Coshocton Co. Frank B. Selby.

860. *Oxalis rufa* Small. Red-leaf Wood-sorrel. Mesopotamia Twp., Trumbull Co. R. E. Shanks.

943. *Hypericum boreale* (Britt.) Bickn. Northern St. John's-wort. Odell Sanctuary, Nile Twp., Scioto Co. Floyd B. Chapman.

960. *Lechea leggettii* Britt. & Holl. Leggett's Pinweed. Braceville Ledge, Trumbull Co. A. N. Rood and R. E. Shanks.

966. *Viola hastata* Mx. Halberd-leaf Yellow Violet. Johnston Twp., Trumbull Co. R. E. Shanks.

987. *Viola fimbriatula* Sm. Ovate-leaf Violet. Vincent, Washington Co. C. F. Walker and J. W. Sites.

1006. *Cerastium viscosum* L. Mouse-ear Chickweed. In a vacant lot. Hillsboro, Highland Co. Katie M. Roads.

1088. *Trientalis americana* (Pers.) Pursh. Star-flower. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1103. *Pleuropterus zuccarinii* Small. Japanese Knotweed. "A large colony on railroad right of way." Blissfield, Coshocton Co. Frank B. Selby.

1139. *Potentilla pumila* Poir. Dwarf Five-finger. Henley, Scioto Co. Katie M. Roads.

1143. *Drymocallis agrimonioides* (Pursh) Rydb. Tall Cinquefoil. Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1152. *Rubus neglectus* Peck. Purple Raspberry. S. W. Bloomfield, Trumbull Co. R. E. Shanks.

1167. *Spiraea prunifolia* Sieb. & Zucc. Bridal-wreath (Spiraea). In a pasture lot. North-western Adams Co. Katie M. Roads.

1178.2. *Rosa foetida persiana* Rehd. Persian Yellow Rose. From western Asia. Along the road, Jackson Twp., Highland Co. Katie M. Roads.

1188. *Prunus mahaleb* L. Mahaleb Cherry. Reily Twp., Butler Co. E. E. Good.

1189. *Prunus pennsylvanica* L. f. Red Cherry. Thompson's Ledge, Geauga Co. F. J. Tyler.

1228. *Crataegus phaenopyrum* (L. f.) Medic. Washington Hawthorn. Section 8, Reily Twp., Butler Co. E. E. Good.

1254. *Trifolium reflexum* L. Buffalo Clover. In dry woods. Liberty Twp. Jackson Co. Floyd Bartley and Leslie L. Pontius.

1264. *Robinia hispida* L. Rose Acacia. Jackson Twp. Jackson Co. Floyd Bartley and Leslie L. Pontius.

1282. *Meibomia marylandica* (L.) Ktz. Maryland Tick-trefoil. Friendship, Scioto Co. R. B. Gordon, J. S. Katz, and F. B. Chapman. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1300. *Vicia cracca* L. Remove Lake and Franklin Cos. from distribution list and add Ashtabula.

1300.1. *Vicia dasycarpa* Ten. (*V. varia* Host.). Variegated Vetch. From Europe. Painesville, Lake Co. Coll., Otto Hacker in 1900. Columbus, Franklin Co. Coll., John Wolfe in 1931. Determined by N. C. Fassett.

1307. *Vicia angustifolia* L. Narrow-leaf Vetch. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1314. *Lathyrus latifolius* L. Everlasting Pea. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1316. *Clitoria mariana* L. Butterfly-pea. White's Gulch, Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1321. *Galacta volubilis* (L.) Britt. Downy Milk-pea. Nile Twp., Scioto Co. F. B. Chapman.

1322. *Phaseolus polystachyus* (L.) B. S. P. Wild Bean. Rock Run, Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius. North Madison, Lake Co. Harry Crofoot.

1344. *Rotala ramosior* (L.) Koehne. Rotala. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1347. *Lythrum salicaria* L. Spiked Loosestrife. On old prairie, three miles west of Marion, Marion Co. E. N. Transeau.

1352. *Rhamnus caroliniana* Walt. Carolina Buckthorn. Hobey Hollow, Nile Twp., Scioto Co. F. B. Chapman.

1359.1. *Vitis labruscana* Bail. Labruscan Vineyard Grape. In a sand dune near the lake beach. Ashtabula Co. Harry Crofoot and F. J. Tyler.

1421. Change name to *Quercus montana* Willd. Rock Chestnut Oak. *Q. prinus* L. is the true name of the Cow Oak not known to occur in Ohio.

1431.1. *Quercus borealis* Mx. f. Gray Oak. In recognizing this form of the red oak group, we have definite specimens from Perry and Madison, Lake Co., F. J. Tyler; along Black River, Lorain Co., F. O. Grover; Liberty Twp., Jackson Co., Floyd Bartley and Leslie L. Pontius; Friendship, Scioto Co., Delzie Demaree.

1432. Change name to *Quercus maxima* (Marsh.) Ashe. Common Red Oak. *Q. rubra* L. is the true name of the Spanish Red Oak, *Q. triloba* Mx.; thus No. 1429 becomes *Quercus rubra* L.

1519. *Circaea alpina* L. Small Enchanter's-nightshade. Liberty Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1525.1. *Cucurbita foetidissima* H. B. K. (*Pepo foetidissima* (H. B. K.) Britt. Wild Pumpkin. Accidental along R. R., growing for at least three years. From the west. Columbus, Franklin Co. Wendell Paddock.

1553. *Chimaphila umbellata* (L.) Nutt. Pipsissewa. N. W. Mesopotamia Twp., Trumbull Co. R. E. Shanks.

1655. *Gonolobus laevis* Mx. Sandvine. Along Tuscarawas River, Coshocton Co. Frank B. Selby.

1656. *Cynachium nigrum* (L.) Pers. Black Swallow-wort. Lake Co. Harry Crofoot.

1672. *Physalis pubescens* L. Low Hairy Ground-cherry. In a pasture lot. May Hill, Adams Co. Katie M. Roads.

1705.1. *Digitalis lanata* Ehrh. Woolly Foxglove. Near Circleville, Pickaway Co. Escaped from cultivation. From Europe. Ethel L. Boyer.

1729. *Veronica polita* Fries. Procumbent Speedwell. Athens, Athens Co. Walter P. Porter.

1751. *Thalesia uniflora* (L.) Britt. Naked Broom-rape. Sharon Twp., Franklin Co. John Wolfe and S. S. Humphrey.

1779.1. *Myosotis versicolor* (Pers.) J. E. Smith. Yellow-and-blue Forget-me-not. Kelley's Island, Erie Co. E. L. Moseley.
1816. *Mentha rotundifolia* (L.) Huds. Roundleaf Mint. Farmer's Station, Clinton Co. Katie M. Roads.
1909. *Thaspium pinnatifidum* (Buckl.) Gr. Cutleaf Meadow-parsnip. Chuckery, Madison Co. L. E. Hicks and E. S. Thomas.
1942. *Cynoxylon canadense* (L.) Dwarf Dogwood. Peat soil, swamp forest. South Bog, Burton, Geauga Co. J. W. Aldrich.
1968. *Sherardia arvensis* L. Blue Field-madder. Hirtland Hills, Lake Co. H. C. Beardslee and F. J. Tyler.
1978. *Viburnum molle* Mx. Soft-leaf Arrow-wood. Sect. 22, Reily Twp., Butler Co. E. E. Good.
2023.1. *Xanthium speciosum* Kearney. Great Cocklebur. Pickaway Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.
2031.2. *Galinsoga ciliata* (Raf.) Blake. Ciliate Galinsoga. Specimens in the herbarium from Lake, Cuyahoga, Lorain, Erie, Columbiana, Jefferson, Belmont, Monroe, Athens, Meigs, Licking, Franklin, Montgomery, Highland, Scioto.
2032. *Galinsoga parviflora* Cav. Small-flowered Galinsoga. After segregating the two species recognized at present for our region, the only specimen in the state herbarium of this species is from Lake Co. Collected by Otto Hacker in 1902.
2050. *Helianthus instabilis* Wats. Unstable Sunflower. Richmond, north of Painesville, Lake Co. F. J. Tyler.
2078. *Bidens discoidea* (T. & G.) Britt. Small Beggar-ticks. Bradley Everett Bog, Burton, Geauga Co. John W. Aldrich.
2089. *Chrysogonum virginianum* L. Chrysogonum. In open oak-hickory woods, Dunham Twp., Washington Co. C. F. Walker and J. W. Sites.
2101.1. *Tagetes patula* L. French Marigold. Spontaneous in waste ground, north Columbus, Franklin Co. Cultivated from Mexico. John H. Schaffner.
2110. *Anaphalis margaritacea* (L.) Benth. & Hook. Pearly Everlasting, Madison, Lake Co. Harry Crofoot and F. J. Tyler.
2121. *Solidago hispida* Muhl. Hairy Goldenrod. Laurel Twp., Hocking Co. Chas. R. Goslin.
2148. *Aster schreberi* Nees. Schreber's Aster. Nile Twp., Scioto Co. F. B. Chapman.
2159. *Aster oblongifolius* Nutt. Aromatic Aster, Marshall Twp., Highland Co. Katie M. Roads.
2165. *Aster concinnus* Willd. Narrow-leaf Smooth Aster. Friendship, Scioto Co. R. B. Gordon, J. S. Katz, and F. B. Chapman.
2169. *Aster vimineus* Lam. Bloomfield Twp., Trumbull Co. R. E. Shanks.
2172. *Aster salicifolius* Lam. Willow Aster. Perry, Lake Co. F. J. Tyler.
2189.1. *Eupatorium album* L. White Thoroughwort. Nile Twp., Scioto Co. F. B. Chapman.

In 1931, just before publication of the Revised Catalog of Ohio Vascular Plants, Dr. M. L. Fernold, of the Gray Herbarium, studied our entire collection of Potamogeton, but because his general report had not been published when the Revised Catalog was placed in the hands of the printer a number of his conclusions could not be included. In July, 1932, Fernald published his monograph of "The Linear-Leaved North American Species of Potamogeton, Section Axillares." in Mem. Gray Herb. Harvard Univ. **3** : 1–183. Below is given a revision of some of the Ohio Potamogetons, agreeing with Fernald's determinations:

98. *Potamogeton epihydrus* Raf. Ashtabula, Trumbull, Medina, Jackson.
98a. *Potamogeton epihydrus nuttallii* (C. & S.). Fern. Doner's Lake, Wayne Co. A. D. Selby.
102. *Potamogeton foliosus* Raf. Leafy Pondweed. Ashtabula, Medina, Lorain, Erie, Auglaize, Champaign, Miami, Montgomery, Hamilton, Scioto, Jackson, Pickaway.

102a. *Potamogeton foliosus macellus*. Fern. Summit, Cuyahoga, Erie, Williams, Logan, Champaign, Licking, Fairfield.
103. Change name to *Potamogeton zosteriformis* Fern.
104. *Potamogeton hillii* Mor. Hill's Pondweed. Ottawa (Mosely Herb.), Portage (Webb Herb.).
104.1. *Potamogeton panormitanus* Biv. Auglaize, Ottawa (U. S. Natl. Herb.), Erie, Summit.
104.2. *Potamogeton strictifolius* Ar. Benn. Stiff-leaf Pondweed. Ottawa (U. S. Natl. Herb.).
105. *Potamogeton friesii* Rupr. Fries' Pondweed. Erie (Moseley and Deam Herbaria), Ottawa (U. S. Natl. Herb.).
107. *Potamogeton pusillus* L. Small Pondweed. Franklin, Ottawa (U. S. Natl. Herb.), Ashtabula.

An Outline of Atomic Spectra

Physical science is a field of shifting interests. Ten years ago the attention of a majority of physicists was fastened on the problems connected with the outer structure of the atom. The solutions to these problems were found by the study of x-rays and line spectra. We have since entered another era in which attention is being directed at the atomic nucleus. This leaves the spectroscopists to themselves to consider more carefully their child, now out of the growing-pains age.

It is surprising that more books on spectroscopy have not been written. Condon and Shortley have written an adequate treatise intended for those who already have a thorough knowledge of the subject. White has written a complicated compendium on the subject. Herzberg, in the book which is the subject of this review, has written an outline. All three books fail to meet the most urgent need of young men entering research in those fields of physics which require a knowledge of spectroscopy.

A careful examination of Herzberg's book convinces the reviewer that it cannot by itself give the student a feeling for the subject. This is primarily the result of the fact that the author has reduced his description of the physical phenomena to a minimum, concentrating his attention on their interpretations. In a condensed outline such as this, the result is a heavy super-structure on an inadequate foundation.

The criticism that must be made of this book is that it misses the greatest need. It is, in fact, a splendid outline clearly written and well organized.

—C. E. Hesthal.

Atomic Spectra and Atomic Structure, by Gerhard Herzberg. xiv+257 pp. New York, Prentice-Hall, Inc., 1937. $4.25.

The Theory of Metals by A. H. Wilson is a book setting forth a rather critical survey of this field of ever increasing importance. The first chapter devotes itself to an historical introduction to the subject giving a brief review of the classical theories of Drude and Lorentz and the first quantum mechanical attempts at solving the problem by Sommerfeld. The second chapter introduces the idea of the Hartree "self consistent field" and the Foch modification to include exchange forces, but concentrates itself especially about the theory concerning the motion of electrons in a perfect lattice. In subsequent chapters these ideas are made use of in discussion of such problems as the optical properties, the conductivity, the resistance and the super-conductivity of metals. Two appendices are devoted to a brief discussion of the Fermi-Dirac statistics and to a sketch of surface phenomena.

This book presents the theory of metals in such a readable and consolidated form that it is to be regarded as a most useful source for the student of physics from which to acquaint himself with this rapidly increasing field.—H. H. Nielsen.

The Theory of Metals, by A. H. Wilson. 271 pp. Cambridge University Press, New York, the Macmillan Co. 1936. $5.00.

TWO NEW SPECIES OF OSBORNELLUS

Dwight M. DeLong and Lawrence Beery,
The Ohio State University, Columbus, Ohio

Osbornellus filamenta n. sp.

Resembling *consors* in general appearance, but darker; slightly smaller and with genitalia quite similar to *borealis*. Length, male, 4.2 mm.; female, 4.5 mm.

Vertex not as sharply angled as in *consors*, as long as basal width between eyes.

Color: Similar to *consors* but much darker. Vertex dark with black markings. Pronotum and scutellum finely mottled dark gray and brown. Elytra clear, veins dark brown. Costal anteapical veinlets and inner ends of claval veins, broadly brown. Central area of cells on disc and second and anteapical cells with elongate brown spots.

Genitalia: In general quite similar to *borealis*. Male plates narrowed to form slender attenuate tips. Styles broad at base, gradually narrowing to slender caudally directed apical portion. Oedagus composed of a rather short dorsal portion below which is a long filamentous, caudally directed process and below this a pair of long, tapered filamentous processes, which are directed caudally. Apices of processes differing distinctly from those of *borealis*, which are angled ventrally and abruptly narrowed at apex.

Described from one male collected at Davis Mts., Texas, Aug. 22, 1936, and one female from the same place, July 6, 1936, by J. N. Knull. Holotype male and allotype female in collection of senior author.

Osbornellus knulli n. sp.

Resembling *consors* in size and general appearance. Genitalia very distinct. Length, 5.5–6 mm.

Vertex about as long as basal width between the eyes.

Color: Similar to *consors* but lacking the distinct markings of vertex and pronotum. Vertex pale with black line along apex, posterior margin white. Pronotum grayish with black markings on anterior margin. Elytra subhyaline, veins brown. Inner ends of claval veins and costal anteapical veinlets, broadly dark brown. Central area of cells on disc and on second and third anteapicals, brown.

Genitalia: Male plates narrowed to form attenuate apical half which is slightly broadened before slender apices. Styles broad at base, narrowing to slender caudally directed apical half. Oedagus composed of a dorsal portion and a pair of broad ventral processes which in ventral view are abruptly narrowed to apices sharply pointed on inner margin. The dorsal process is curved anteriorly on the basal half, and caudally on the apical half which is composed of a short dorsal spur and a much longer, broader, caudally directed process upturned and pointed at apex.

Described from two males and one female, all taken in Huachuca Mts., Ariz., July 20, 1936, J. N. Knull. Holotype male, allotype female and male paratype in collection of senior author.

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EXAMPLES OF ORTHOGENETIC SERIES IN PLANTS AND ANIMALS

STUDIES IN DETERMINATE EVOLUTION X*

JOHN H. SCHAFFNER

Orthogenetic series are so prominent in both the plant and animal kingdoms that their consideration becomes of major significance in any careful study of the evolution of organisms. A few types of plant series are here presented together with several animal series in order to illustrate the nature and significance of orthogenesis. In studying living organisms one cannot tell directly, from the orthogenetic series itself, what is the real relationship of the members of a series to one another nor in what sequence they evolved; but this is after all of secondary importance. The fundamental problem is the fact that the evolutionary process brings out such a series and that these series usually have no relation either to utilitarian advantage or to any ecological conditions either physical or biological. The evolution of each series is commonly independent of other movements in the same group of organisms and may even proceed in a different direction or in a sequence exactly the opposite. In the past the most definite orthogenetic series were recognized in the fossil records and in these, of course, the direction of any given movement or sequence was definitely indicated by the succession of the rock strata in which the fossils were found.

In attempting to explain orthogenetic series in the past it was usually assumed that the series was the result of natural selection or was produced by ecological sequences, either in time or space by a direct effect of the environment. However, any one who has only a superficial knowledge of orthogenetic series and their taxonomic relations soon discovers that they have no general correspondence with any ecological gradations, whether considered from the standpoint of the Darwinian survival of the fittest, of a direct response to environment, or of a fancied Lamarckian use or disuse. Most of the series are found to lie entirely outside of any possible teleological implications, and have no more to do with advantageous or utilitarian determination than have the many interesting series of molecules often met with in organic chemistry or the various series of forms and patterns appearing in certain types of crystallization.

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*Papers from the Department of Botany, The Ohio State University, No. 380.

Recently certain geneticists have attempted to resurrect the natural selection corpse and to develop a new type of evolutionary theory based on the fortuitous mutations of genes and a utilitarian selection. But this genetic hypothesis is again entirely beside the mark, for it does not touch the fundamental problems of the taxonomic system nor the taxonomic series with which the systematist has to deal. No simple external physical agent postulated as a fundamental cause of evolution, as X-rays, cosmic rays, ultra-violet rays, etc., can receive any serious consideration from any biologist who has some general knowledge of the organic kingdom; because it is evident that it is impossible logically to depend on random and universal agents, like the various radiations, to account for the fundamental fact of orthogenetic series when these series show no zonal arrangement in relation to supposed causal agents. It is a well-known fact that in ecological zonation of plants there can be, and usually is, a haphazard assemblage of diverse taxonomic types in the same zone which in itself shows that the taxonomic structures have neither been produced as a result of the environment nor been arranged in the zones because of taxonomic relation.

Any theory of evolution worthy of the consideration of any serious-minded biologist must also take account of the fundamental biological realities which go much deeper than the mere matter of speciation.

ORTHOGENETIC SERIES IN PLANTS

One of the decided and oft-repeated orthogenetic series to be observed in the flower is the progressive reduction of the floral members until the determinate limit is approached or reached for some essential organ. In the Alismatales, for example, *Echinodorus radicans* (Nutt.) Engelm. has about 20 stamens; species of *Lophotocarpus* have 15–9; *Helianthium* *parvulum* (Engelm.) Small has 9; *Alisma plantago* L. has 6; *Potamogeton* species have 4; *Ruppia maritima* L. has 2; *Zannichellia palustris* L. and species of *Naias* have but a single stamen in the staminate flower. In this series the progression is to completely submerge plants and hydrophilous pollination, from an aerial habitat and entomophilous pollination. Now, in the anemophilous, aerial grasses, most of the bamboos have 6 stamens or sometimes even more to the flower; *Arundinaria* and the lower herbaceous grasses have 3, *Andropogon scoparius* Mx. has 3, *Andropogon elliottii* Chapm. has 1. Various entomophilous groups show the same sequence. In the Orchidales, *Thismia* has 6 stamens, *Neuwiedia* 3, *Cypripedium* 2, *Arethusa* and hundreds of other orchid genera have 1. In the Scitamimales, *Ravenala* has 6 stamens, *Musa* sp. 5, *Hedychium* and *Alpinia* 1, *Canna* and *Maranta* have only a half fertile stamen in the flower. Such series appear in numerous other monocotyl groups. Thus it will be seen that whether the plants pass under the water or remain in aerial conditions, whether the flowers are bisporangiate or monosporangiate, whether pollination is hydrophilous, anemophilous, or entomophilous, the results are the same in the evolutionary series in so far as the stamens are concerned. Neither the series as a whole nor any special member of the series shows any relation to the environment nor any advantage or disadvantage of one type over another. All of these species with one or with a half stamen are successful. There is no such thing as adaptation or utility in evidence as having any causal relation to the series. The same condition of things is evident in many lines of dicotyls. Taking for example a common dry land weed series in the Centrospermae: *Agrostemma githago* L. has 10 stamens, *Alsine media* L. 10–2, *Chenopodium album* L. 5, *Chenopodium rubrum* L. 2–1, *Monolepis nuttalliana* (R. & S.) Greene 1.

In certain groups the embryos of various species make a progressive series from straight to very decidedly coiled. A series in which the embryos develop under water is as follows: *Naias flexilis* (Willd.) R. & S. embryo straight, *Potamogeton heterophyllus* Schreb. embryo curved, *P. compressus* L. embryo slightly spiral, *P. diversifolius* Raf. embryo coiled, *P. dimorphus* Raf. embryo spirally coiled. This series may be compared with a series of common weeds of dry fields: *Polygonella americana* (F. & M.) Small, embryo straight or nearly so, *Rumex* sp. embryo slightly curved; *Polygonum* sp. embryo curved; *Cheno-*

podium ambrosioides L. embryo curved in an incomplete ring; *C. album* L. embryo forming a complete ring; *Sarcobatus vermiculatus* (Hook) Torr. embryo coiled into a flat spiral; *Salsola pestifer* Nels. embryo coiled into a conic spiral. The degree of coiling has neither significance of advantage or disadvantage in itself nor in relation to the environment. The two series occur in the two most extremely diverse ecological conditions imaginable. No "natural selection" nor utilitarian response to the environment had anything to do as a causal agent with the result.

Various monocotyl groups show a progressive union of the perianth segments. In *Aloe haworthioides* Bak. and *A. pratensis* Bak. the perianth segments are entirely free; in *A. myriacantha* (Haw.) R. & S. the perianth segments are only slightly united at the base; in *A. chloroleuca* Bak. the segments are united about one-fourth; in *A. somaliensis* C. Wright they are united about one-third; in *A. rubrolutea* Schinz the segments are united one-half; in *A. shimperi* Todaro they are united two-thirds; in *A. marshallii* W. & E. they are united three-fourths; and in *A. leptophylla* N. E. Brown the perianth segments are united more than four-fifths of their length. Nearly all of these species are South African.

In the Eriocaulaceae, there is a characteristic orthogenetic series in the change from ordinary petals to petals changed to a pappus or mass of hairs. This series is well represented by the petals of the carpellate flowers of the following species: 1, *Eriocaulon guianense* Koern.; 2, *E. longifolium* Nees.; 3, *E. crassiscapum* Bong.; 4, *E. woodii* N. E. Br.; 5, *E. majusculum* Ruhl.; 6, *E. griseum* Koern.; 7, *Lachnocaulon anceps* (Walt.) Morong. The extreme forms give an unusual type of flower with the petals represented by hairs between the calyx and gynecium. The sepals may also be similarly affected; but usually to a much less degree than the petals.

A common character in many genera of grasses is the presence of an awn on the lemma. These awns are of various lengths from mere points to structures of decided prominence. Thus in the genus *Bromus* the following series is to be observed: *B. inermis* Leyss has no awn; in *B. unioloides* (Willd.) H. B. K. the lemma has an awnpoint less than 1 line long; *B. kalmii* Gr., awn 1–1½ lines long; *B. purgans* L., awn 2–3 lines; *B. asper* Murr., awn 3–4 lines; *B. secalinus* L., awn 4 lines but sometimes awnless; *B. patulus* M. & K., awn 4–5 lines; *B. sterilis* L., awn 6–9 lines. A number of species of *Agrostis* in eastern North America have awns as follows: *A. perennans* (Walt.) Tuck. has no awn on the lemma; *A. hyemalis* (Walt.) B. S. P., sometimes awnless, sometimes with a very short awn; *A. geminata* Trin., awn 1 line long or less; *A. canina* L., exserted awn 1–2 lines; *A. borealis* Hartm., awn 2–2½ lines; *A. elliottiana* Schultes, awn 3–4 lines. *Festuca*, *Elymus*, *Muhlenbergia*, *Oryzopsis*, and *Andropogon* present similar conditions. Why these various specific lengths of these appendages? They are of no advantage or disadvantage. The species without awns are just as successful as those with awns; the short-awned species are just as good as the long-awned. But the orthogenetic series is definitely present and it must be considered without any fantastic hypothesis of teleological adaptation. To claim that such structures are of selective value presents the height of philosophical credulity; to see in them a response to environment is equally absurd. Nevertheless the evolutionary process is such that awns are evolved in the various species and these awns appear in various lengths, making the orthogenetic series.

The pods in the Brassicales are sometimes sessile and sometimes stalked. The stalks are also developed in various lengths. Brassicaceae—*Alliaria alliaria* (L.) Britt. has the pod sessile in the calyx; *Thelypodium integrifolium* (Nutt.) Endl., pod short-stipitate; *Stanleya pinnata* (Pursh) Britt., pod long-stipitate. Capparidaceae—*Polanisia graveolens* Raf., pod sessile in the calyx; *Cristatella jamesii* T. & G., stalk of pod 2 lines long; *Cleomella angustifolia* Torr., stalk of pod 3–4 lines; *Cleome serrulata* Pursh, stalk of pod 6–8 lines; *Cleome spinosa* L., stalk of pod 2–6 inches long.

In the evening primrose family as well as in some other groups, the epigynous hypanthium develops from nothing up to 7 inches or more in length. The following represents a series of various lengths: *Jussiaea* and *Chamaenerion* have no hypanthia; *Kneiffia linifolia* (Nutt.) Spach., hypanthium less than ¼ in. long; *Kneiffia longipedicellata* Small, hypanthium ½ in.; *Oenothera oakesiana* Robb., hypanthium 1 in. long. *Oenothera biennis* L., hypanthium up to 1½ in long; *Taraxia breviflora* Nutt., hypanthium up to 2 in. long; *Pachylophus canescens* Piper, hypanthium 3 in. long; *Oenothera longissima* Rydb., hypanthium 4 in. or more long; *Megapterium missouriense* (Sims) Spach, hypanthium up to 6 in. long; *Pachylophus caespitosa* (Nutt.) Rain., hypanthium up to 7 in.

long. A similar condition is represented by species of the Amaryllidaceae. *Leucojum vernum* L. has no perianth tube; in *Lophiola americana* (Pursh) Cov. the perianth segments are slightly united at the base; *Narcissus pseudo-narcissus* L. has a definite hypanthium ½ in. long; *Narcissus odorus* L., hypanthium ¾ in.; *Narcissus poeticus* L., hypanthium 1 in.; *Cooperia drummondii* Herb., hypanthium 1½ in.; *Hymenocallis occidentalis* (LeC.) Kunth, hypanthium 2 in.; *Crinum asiaticum* L., hypanthium 2¾ in.; *Hymenocallis macrostephana* Bak., hypanthium 3 in.; *Crinum amabile* Don., hypanthium 4 in.; *Hymenocallis kimballiae* Small, hypanthium 6½ in.; *Hymenocallis collieri* Small, hypanthium up to 7½ in. long. Again we see a gradation series of lengths in the same genus or closely related genera and in the same general environment. The moths, butterflies, and other insects get nectar from these tubes provided they have a proboscis or tongue long enough to fit the given case or can tear the tube open. But whether they obtain nectar or not, the mere act of alighting on the flower will induce pollination, since the stigmas and anthers are at approximately the same level above the tube of the hypanthium. Moths could survive because as the orthogenetic process brought out all sorts of lengths of probosces in the insects a similar orthogenetic movement was bringing out endless sorts of flowers with longer or shorter tubes, and it is evident that a moth with a long proboscis can very readily sip nectar from a flower with a very short tube as well as from one with a long tube. These orthogenetic series of nectar tubes have no significance in survival. To indulge in fantastic teleological speculations in respect to these developments does not explain why the whole orthogenetic series survived nor the fact that many flowers without nectar tubes or nectar are still visited by numerous insects bent on gathering pollen.

The Orthogenetic Series in the evolution of the solid or adnate hypanthium in Iris shows conclusively that the hypanthium in Iris was not produced as a "special adaptation" to prevent "unbidden guests" from pilfering the nectar reserved for moths with long probosces. The nectar is at the top of the solid hypanthium in this case.

1. *Iris xiphium* L. has no hypanthium. 2. *I. sibirica* L. has a tubular hypanthium ⅛–¼ in. long with no solid lower portion. 3. *I. ensata* Thunb. has a hypanthium ¼ in. long, the lower ⅛ in. being solid. 4. *I. versicolor* L. and *I. pseuda-*

corus L. have hypanthia about ½ in. long, ¼ in solid, and ¼ in tubular. 5. *I. chamaeiris* Bertol. has a hypanthium 1 in. long. 6. *I. cristata* Ait has a hypanthium 2¾ in. long, the solid portion being 2½ in. and the upper tubular portion ¼ in. 7. *I. reticulata* Bieb. has a hypanthium 3 in. long. 8. *I. unguicularis* Poir. has a hypanthium up to 6 in. long.

In addition to developing hypanthia, the species of Narcissus evolved a new structure, the crown, on top of the hypanthium. Since this is a new morphological structure, the evolutionary movement also brings out crowns of various lengths in an orthogenetic series independently of the length of the hypanthia on which they develop. *Crinum asiaticum* L. has no sign of a ridge or crown on the top of the hypanthium; *Narcissus jonquilla* L. has a short crown not over ⅛ in. long; *N. triandrus* L., crown ¼–½ in.; *N. pseudo-narcissus* L., wild variety, crown 1 in. long, cultivated varieties, crown up to 2 in. long. All the many species and varieties of *Narcissus* have crowns ranging within this series.

In the Ranunculaceae, various genera develop nectar pits or spurs on the petals, while other quite similar genera have no pits or spurs. The nectar spurs are prominent in *Aquilegia*. Just as in the case of length of awns or length of hypanthia these nectar spurs form an orthogenetic series. In the genus *Anemone* there are no nectar pits on the perianth segments. *Myosurus minimus* L. and species of *Ranunculus* have small pits at the base of the petals about 1 line deep; *Heleborus viridis* L. has petal tubes 2 lines deep; *Aquilegia eastwoodiae* Rydb. has the petals merely saccate, not spurred; *A. brevistyla* Hook. has nectar spurs about 3 lines long; *A. glandulosa* Fisch., nectar spurs 3–6 lines; *A. sibirica* Lam., nectar spurs 6–9 lines; *A. canadensis* L., nectar spurs 8–10 lines; *A. formosa* Fisch., nectar spurs 9–12 lines; *A. skinneri* Hook., nectar spurs 1½–2 in.; *A. chrysantha* Gr., nectar spurs 2–2½ in. long; *A. longissima* Gr. has a spur 5 in. long. As in the evening primrose, the pollination does not depend on whether the insect can reach the nectar in the bottom of the spur. If the insect alights on the flower, pollination will be accomplished. In this connection one may recall the fantastic notions of "favored and unbidden guests." I have seen bumblebees and honeybees attempting to get at the nectar of the long-spurred columbines without success, but in the meantime pollination was accomplished as readily as if a long-proboscis hawkmoth had hovered over the flowers and sipped the cup of nectar.

One meets with orthogenetic, perfection series in many different types of structure. The glandular pits on the backs of the leaves of species of *Cupressus* show such a series. *Cupressus goveniana* Gord. has glandless leaves; *C. macrocarpa* Hartw. has the leaves glandless or obscurely pitted; *C. guadalupensis* S. Wats., leaves with a dorsal pit but not resin-glandular; *C. macnabiana* Murr., leaves with a conspicuous gland on the dorsal surface secreting resin; *C. glabra* Sudw. leaves with a very conspicuous resin-secreting gland on the back.

There is an orthogenetic series in relation to those extraordinary developments, the pollinia, in the Orchidales. *Thismia hyalina* (Miers) B. & H. has round, smooth pollen grains of the ordinary type. In the main subfamily of Orchids, the Orchidatae, *Cephalanthera grandiflora* (Scop.) Bab. also has granular pollen of the ordinary type. *Arethusa bulbosa* L. has powdery-granular pollen; *Corallorrhiza wisteriana* Conrad, pollinia soft waxy without a caulicle; *Liparis liliifolia* (L.) Rich., pollinia two in each anther sac smooth and waxy, in pairs slightly united but without a stalk, thread, or gland; *Tipularia unifolia* (Muhl.) B. S. P., pollinia ovoid, two in each anther-sac, separate, affixed to a short stipe which is glandular at the base; *Coeloglossum bracteatum* (Willd.) Parl., pollinia oblong-ovoid, with a long caulicle having a glandular base but scarcely wider than the caulicle; *Galeorchis spectabilis* (L.) Rydb., pollinia oblong, granulose, one in each anther-sac, with a slender caulicle having a large glandular disc at its base; *Lysias orbiculata* (Pursh) Rydb., pollinia with a prominent caulicle having an orbicular glandular disc at its base. Thus we see within the closely related plants of a single subfamily a closely graded perfection series of this extraordinary structure and the degree of perfection has nothing to do with survival of the species and there can be no selective action because the whole series is present from zero to the highly elaborated mechanism. In the Apocynaceae-Asclepiadaceae there is a somewhat similar progression from waxy pollen to the highly elaborated pollinia of Asclepias.

In the genus *Araucaria*, the widths of the leaves of the various species form an orthogenetic series from *A. araucana* (Mol.) Koch. with large broad leaves, thru *A. bidwillii* Hook. and *A. cunninghamii* Ait. to *A. excelsa* R. Br. with awl-shaped, vertically compressed leaves. Similar series occur in a number of other groups of Conifers. There is also a progressive series of leaf widths in the *Populus-Salix* group from very broad to very narrow, as illustrated by the following species: *Populus deltoides* Marsh., *P. italica* Moench, *P. alba* L., *P. acuminata* Rydb., *Salix lucida* Muhl., *S. pentandra* L., *S. amygdaloides* And., *S. nigra* Marsh., *Populus angustifolia* James, *Salix interior* Row. The last two "mimic" each other very closely in size, shape, surface, and petiole length. Mimicries are the result of parallel or duplicate orthogenetic evolutions or sometimes of a mere accidental development of form, color, or structure, sometimes in closely related groups, sometimes in groups far apart in relationship, sometimes in the same geographic region, sometimes in regions widely separated. There is no evidence of "mimicry" in the old teleological sense. Such speculations, indulged in at great length by the older school of selectionists, were merely fantastic exercises of the imagination of the same scientific import as the imaginary designs of birth marks of fruits, leaves, seeds, plum pits, flames, etc., which the superstitious believe are caused by strong mental impressions of the mother during pregnancy. There is no more scientific evidence for a belief in selective mimicry than there is for the supposed prenatal influence of the mother's mind in determining birth marks.

In various groups there is an orthogenetic series in the development of the lobing of the petals, ranging from petals with rounded tips to very deeply divided petals. Such a series is present in the chickweed alliance as shown by the following: *Arenaria stricta* Mx., *A. hookeri* Nutt., *Cerastium semidecandrum* L., *Alsine holostea* (L.) Britt., *A. longipes* (Goldie) Cov., *A. media* L. (Fig. 1). Certainly no one with any knowledge of ecological relations would believe that any of these notched, lobed, or divided petals which make up the series are of any special advantage or environmental "adaptation."

The remarkable insectivorous leaf of *Drosera rotundifolia* L. has been widely exploited by teleologists. There is no question about its seemingly perfect "adaptation" for catching small insects. But when the genus is studied as a whole, *D. rotundifolia* is found to be but the end of an orthogenetic series, the preceding members of which, especially the first ones, are poorly fitted for catching insects. In fact the lowest are no more successful in this respect than great numbers of plants which have glandular or glutinous hairs or surfaces on the leaves or stems or in the inflorescence. A good series is represented by the following species: *Drosera filiformis* Raf. with slender filiform leaves as the name implies; *D. linearis* Goldie, leaf blades linear; *D. longifolia* L., blades elongated spatulate; *D. intermedia* Hayne, blades short spatulate; *D. rotundifolia* L., leaf blades orbicular, abruptly narrowed into a flat, pubescent petiole. Thus it is seen that there are all degrees of this peculiar "adaptation" and that all have survived in their bog habitats. There has been no selection of the fittest at the expense of the less fit or the decidedly unfit in respect to the ability to catch insects. There has been no similarity in leaf form or perfective mechanism in relation to environment, but there has come out of the evolutionary process a very interesting orthogenetic series, and this series exists and calls for consideration no difference whether it evolved, step by step, in the direction toward the perfected devise, or whether the members of the series mutated in an irregular manner. Finally it is doubtful whether there is any real advantage to the plant in the capturing of insects or other small creatures.

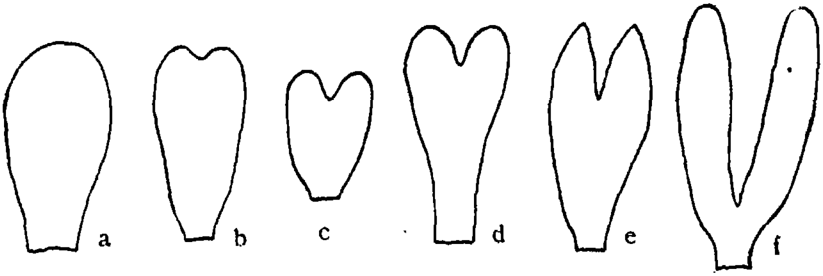

Fig. 1. Orthogenetic series in the division of the petal of closely related species in Caryophyllaceae. a, Entire petal of *Arenaria stricta* Mx. b, Slightly emarginate petal of *Arenaria hookeri* Nutt. c, *Cerastium semidecandrum* L. d, *Alsine holostea* (L.) Britt. e, *Alsine longipes* (Goldie) Cov. f, Divided petal of *Alsine media* L.

The evolution of the inflorescence also produces progressive series in many groups, as for example, in *Acer* and *Prunus*. *Acer pennsylvanicum* L. has a receme; *A. platanoides* L. a corymb; *A. saccharum* Marsh. an umbellate corymb; *A. saccharinum* L. an umbel-like cluster. *Prunus virginiana* L. has a raceme; *P. mahaleb* L. a corymbose inflorescence; *P. americana* Marsh. an umbel or fascicle; *P. spinosa* L. umbel reduced to 1–2 flowers.

One of the most peculiar and extreme types of fruits is the syconium or fig-fruit of the Common Fig, *Ficus carica* L., which represents a hollow or bottle-like, fleshy stem or inflorescence receptacle with the apex of the stem at the base of the cavity and with numerous flowers on the walls within. This type is a long distance away from the common type of fleshy ament as in species of *Morus*. In this case also the fig fruit does not represent a survival by selection or direct response to environment through the elimination of the less fit but is the end product of an evolutionary movement which produced another remarkable orthogenetic progression, practically all the general steps in the series being represented by living representatives. A few years ago it was the writer's good fortune to see a number of the species of the series in fruit at the Kew Gardens, England. The series may be illustrated by the following species: *Morus alba* L., *Dorstenia psilurus* Welw., *D. yambuyaensis* De Wild; *D. arifolia* Lam., *D. alata* Gardn., *Ficus carica* L. The fruit of *Dorstenia elata* Gardn. is a deep cup-like receptacle, while as is well known the fruit of *Ficus* has only a minute opening at the tip.

Various groups of plants show series of progressive flattenings of the stem and the development of two lateral wings from the ordinary cylindrical type. Such a series was outlined in a former paper of the "STUDIES." Extreme flattenings are represented by *Sisyrinchium grammoides* Bickn. and *Marica gracilis* Herb. belonging to the Iris Family. The genus *Lathyrus* of the Bean Family also shows species with progressive flattening of the stem with two wings as follows: *Lathyrus maritimus* L. and *L. venosus* Muhl. have the stem angled but not winged; *L. palustris* L. and *L. macranthus* (White) Rydb. have the angled stem slightly winged; *L. pusillus* Ell. and *L. grandiflorus* Sibth. and Sm. have the stem winged; *L. odoratus* L. has the stem prominently winged; *L. latifolius* L. has the stem broadly winged.

In various groups of Cacti there are progressive series from cylindrical to decidedly flattened stems, in the extreme types associated with a 2-ranked phyllotaxy. *Opuntia imbricata* (Haw.) Engelm., a tree Prickly-pear, has cylindrical stems; *O. fragilis* (Nutt.) Haw. joints somewhat flattened; *O. macrorrhiza* Engelm. joints decidedly flattened; *Epiphyllum oxypetalum* (DC.) Haw. (*Phyllocactus latifrons* Link) branches flat and thin, *Zygocactus truncatus* (Haw.) Schum., Christmas Cactus, joints exceedingly flattened and thin. In the genus *Ripsalis* there is a series of species from *R. virgata* Web. with

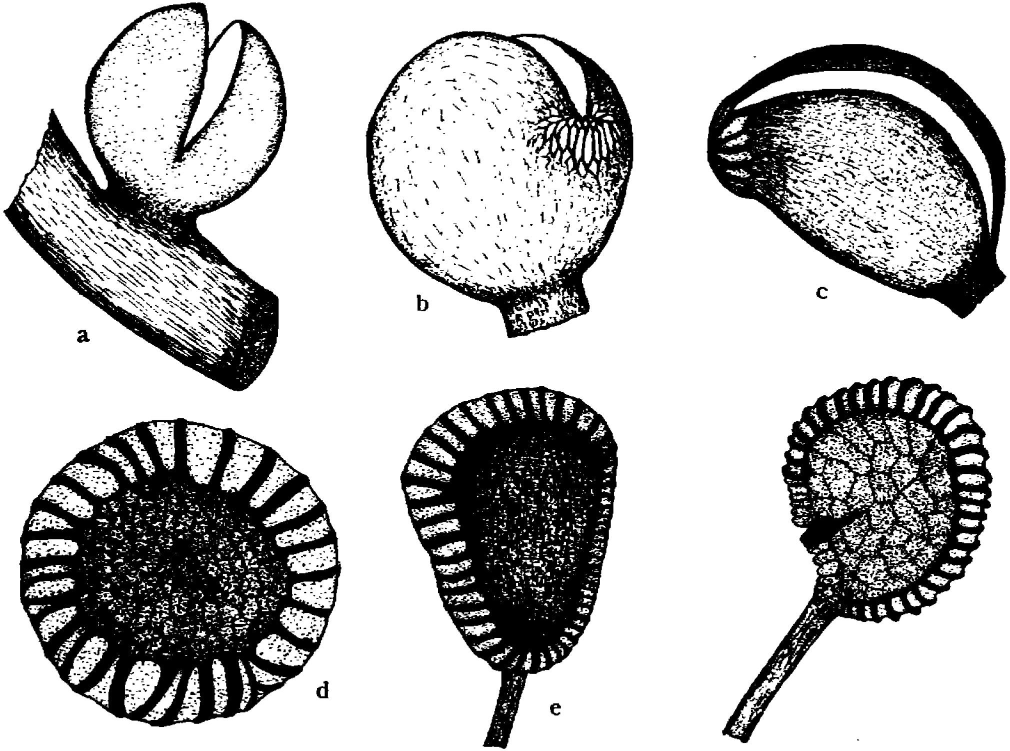

Fig. 2. Orthogenetic series in the evolution of a spore-throwing mechanism in the ferns. a, Sporangium of *Botrychium obliquum* Muhl. b, *Osmunda regalis* L. c, *Aneimia tomentosa* Sw. d, *Gleichinia longissima* Blume. e, *Cibotium chamissoi* Hk. & Bkr. f, *Onoclea sensibilis* L.

cylindrical stems to more and more flattened-stem forms, until in *R. elliptica* Lundb. and *R. russellii* Britt. and Rose the joints are very flat and thin.

Even the evolution of the mycorrhizal inter-relationship of fungus and root may show an orthogenetic series. J. Ramsbottom[1] in his study of mycorrhiza in the heaths says: "In the root-tip region we get an ascending series in the amount of fungus present from *Chimaphila umbellata* where the epidermal cells of some roots are without hyphae and other roots with hyphae, but not in every cell, to *C. maculata* with a greater number of the epidermal cells filled with hyphae; in *Pyrola rotundifolia* and *P. elliptica* all the cells are infected and there is the beginning of intertwined hyphae round the root tip; then in *Monotropa hypopitys* an increase in the width and extent of the sheaths and a division into two zones—an outer loosely woven mass of hyphae and an inner more compact one—and finally in *M. uniflora* a still greater width of the fungal sheath. In the least saprophytic species the epidermis soon dies off, carrying with it the fungal hyphae as in Chimaphila and Pyrola, whereas in Monotropa, especially *M. uniflora,* the epidermis is still living and filled with hyphae when the root is quite old. Corresponding with this increase in saprophytism there is an increase in the number of seeds produced and a reduction in their size and structure." It will be noted that a loss of chlorophyll is also involved in the more advanced species and that the simplification of the plant body and inflorescence and leaf structures attain their extreme limit also in *M. uniflora.*

AN ORTHOGENETIC SERIES LEADING TO A HIGHLY PERFECTED MECHANISM OF NO SURVIVAL VALUE TO THE INDIVIDUAL

The ferns have evolved a series of sporangia which represents a progression toward perfection in a mechanism which throws out the mature spores suddenly, by means of a hygroscopic ring of cells around the sporangium. The extreme type represents a very efficient and elaborately perfected structure which does the plant no good, for those species which are at the bottom of the series are just as successfully distributed as those with the perfected mechanism. Such a series is illustrated in Fig. 2. *Botrychium obliquum* Muhl. has a

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[1] Ramsbottom, J. Trans. British Mycol. Soc., 8: 28–61. 1923.

sporangium which merely opens by a simple slit and the spores fall out by accident (a). In *Osmunda regalis* L. the sporangium is nearly the same shape, also with a vertical slit, but at one side at the end of the dehiscence slit there is a peculiar group of cells with thickened walls (b). This group of cells represents the first step in the evolution of a remarkable structure, the annulus. So far as spore scattering is concerned, *Botrychium* can scatter its spores just as readily as *Osmunda* with the special patch of cells in the wall of the sporangium. In *Aneimia tomentosa* Sw. there is a decided advance in the group of thick-walled cells over that in *Osmunda* and is now arranged in the form of a ring at one end of the sporangium, the dehiscence still being by a vertical slit (c). In *Gleichinia longissima* Blume the sporangium has a complete ring of highly specialized cells (d). The figure represents a sporangium from the top. In *Cibotium chamissoi* Hk. and Bkr. there is also a complete ring which passes vertically around the sporangium to one side of the stalk (e). The cells on one side of the ring are much more elaborately developed than on the other. This sporangium is approaching the ideal type developed in the Polypodiaceae. In *Onoclea sensibilis* L. and many other Polypodiaceae there is a highly evolved incomplete ring with special lip cells on one side and cells with extremely hygroscopic walls on the other (f). When the sporangium is mature the hygroscopic ring, by turning back and straightening out, tears the sporangium open gradually but quickly and then suddenly collapses again with a jerk, thus throwing out the spores. A more perfect and ingenious mechanism for the purpose, and with the limited material employed, can hardly be imagined; but this perfected spore thrower is of no importance to the fern in giving it any advantage in distribution or survival. *Botrychium virginianum* (L.) Sw. is just as widely distributed and just as abundant if not more so, as *Onoclea sensibilis* L. It will be noted also that *Onoclea* has the pinnules which bear the sporangia rolled up into berry-like segments, which although they open up at maturity nevertheless must interfere decidedly with the scattering of the spores by the annulus mechanism. In the Hawaiian fern, *Cibotium chamissoi* Hk. and Bkr. the indusium forms a thick-walled box-like two-lobed structure with one lobe forming an open valve or lid for the other which holds the cluster of sporangia. Although the lid of the box opens up at maturity, this highly developed indusium must interfere decidedly with the free discharge of the spores in the same way as the enrolled pinnule of *Onoclea*. At best, even with no special obstruction, the spores can be thrown only a short distance and their wide distribution is accomplished by wind, water and animals, which carry the spores of ferns like Botrychium without any throwing device as effectively and as widely as those with the perfected spore-throwing mechanism. The highly elaborated spore-throwing sporangium then is of no advantage to the plants which possess it but simply represents the end product of a perfective, evolutionary, orthogenetic series which came to perfection through intrinsic processes and causes.

SOME SIMPLE ORTHOGENETIC SERIES OF ANIMALS

Plants and animals form one organic system and the laws of heredity and evolution are the same fundamentally for both kingdoms. Since the higher plants are simpler in their organography and anatomy and especially since most plants have indeterminate and repetative growth, they are more convenient and reliable for the discovery of the true nature of heredity and evolution in general than the animals with their rapidly determinate ontogeny, which in all the higher forms do not give rise directly to new individuals by a normal process of budding and continuous growth as is common in plants. However, when one examines series of related animal species, either in the paleontological record or by a comparison of living forms, one finds on every side the same kind of orthogenetic series in the evolution of organisms and tissues as in plants. A few examples will be considered below for comparison with plant series. The presence of orthogenetic series was first studied intensively by paleontologists who could not escape the very clear cases presented by the degrees of coiling of Cephalopod shells, the development of complexity of the sutures in the shells of Ammonoids, the progressive change in the feet of the ancient horse series, the progressive evolution of the cusps of the teeth of mammals, and numerous other paleontological problems of a similar nature.

The Lamellicorn Beetles (Scarabaeidae) have a peculiar backward-projecting horn on the head or thorax which is evolved in various lengths in different species. *Canthon laevis* has no horn on the head or thorax. In *Copris tullius* the female has a short tubercle on the head and the male has a short horn. In *Xyloryctes satyrus* the female has a slight point on the head and the male has a horn of medium length. In *Copris arizonensis* the female has a short spatulate horn on the head and the male has a prominent horn. In *Phanaeus carnifex* the female has a short blunt tubercle on the head while the male is provided with a long curved horn. In *Phanaeus quadridens* the female has a short blunt point on the head while the male has a very long horn. So all the horns of the males of these beetles and their relatives form a close orthogenetic series of lengths which give no advantage to the individual possessing the one type or another. The notion of special adaptation is not to be entertained rationally. The sex dimorphism present in these species was not originated because the female delights in a mate with long horns or because he can protect her and himself but because the two sexes are on a different metabolic level. Exactly similar phenomena can be observed between male and female structures in plants. Thus in the monecious *Zizania aquatica* L. the staminate spikelets are awnless while the carpellate spikelets have long awns.

The long-horned Wood-boring Beetles (Cerambycidae) as well as many other groups of insects present an orthogenetic series in the lengths of their antennae. *Moneilema varolare* and *Xylotrechus colonus* have rather short antennae, considerably shorter than the body. *Acanthocinus spectabilis* and *Monochamnus notatus* have antennae much longer than their bodies. Other long-horned wood-boring beetles take their positions in this series with all sorts of lengths of antennae. These various lengths are of no special value, but after the beetle has antennae of a given length it, of course, must accommodate its life and movements to the restrictions, advantages, or disadvantages of the length possessed or be eliminated in the struggle if the given length has any determinate effect, which seems improbable since the whole series of lengths has proven successful.

Among the important structures present in some groups of moths is the proboscis which also comes in series from zero to a structure of great length in the hawk moths (Sphingidae). The proboscis consists of the greatly lengthened maxillae and is useful for sucking nectar from flower cups and spurs. The lowest types of moths do not have a sucking proboscis. In *Sabatinca* sp. (Micropterygidae) the mandibles are functional dentate organs. In *Eriocrania* sp. (Micropterygidae) the mandibles are non-dentate and the terminal joint of the galea of either side is opposed to that of its fellow, thus exhibiting the first step in the formation of a proboscis. In some forms of the Sphingidae the proboscis is also represented by a pair of tubercles, which is usually considered as representing a reduced condition, but there is no evidence that it was ever derived from an originally highly evolved proboscis. Now from these primitive conditions there are moths with proboscis of all sorts of lengths. *Protoparce quinquemaculata*, the common tomato-worm moth, has a proboscis 5–6 inches long. In *Cocytius proboscis* the proboscis is said to attain the enormous length of 10 inches. Here then is a remarkable orthogenetic series of lengths of an essential organ which runs parallel with various series of lengths of corolla tubes and spurs. Of course, it is evident that the moths with the longest probosces can sip nectar from the longest flower tubes and spurs, but they can and do also gather the nectar from flowers with comparatively short tubes. And such flowers are much more common in all areas than those with very long tubes. Thus the long proboscis has not evolved thru any adaptive necessity, and as stated above the flower with long tubes and spurs will be pollinated by the general swarm of pollen and nectar eating insects whether they are lucky enough to reach the nectar or not.

In various groups of wasps the thorax is separated from the abdomen by a slender connective or peduncle. This extraordinary structure which separates the front end of the body from the back end also comes in an orthogenetic series, as might be expected. In *Sphecius speciosus* the thorax and abdomen are contiguous. In *Chrysis ignita* there is no prolongation of the connective but nevertheless a distinct separation of the thorax and abdomen. *Priononyx atrata* has a short connective. *Chlorion coeruleum* has a connective about one-half as long as the abdomen. *Eumenes petiolata* has a connective longer than the abdomen. *Ammophila sabulosa* has a connective about twice as long as the abdomen. To see any special advantage in such a condition is to proclaim one's self a firm believer in witch stories and fairy tales.

Mammals exhibit orthogenetic series in the lengths of their tails. Among the Ground Squirrels, the California Ground Squirrel (*Otospermophilus grammurus beecheyi*) has a tail 7 in. long. The Yukon Ground Squirrel (*Citellus osgoodi* has a tail 5–6 in. long. The Franklin Ground Squirrel (*Citellus franklini*) has a tail 5 in. long. The Apache Ground Squirrel (*Citellus spilosoma macrospilotus*) has a tail 3 in. long. Other species of Citellus and other genera of ground squirrels have tails of various lengths which can all be arranged in orthogenetic series and have no relation to advantage or disadvantage to the animals in their various geographic regions and habitats.

The Lemurs live mostly in Madagascar. Their tails, which are never prehensile, show a very striking orthogenetic series. Three species which are nocturnal tree-dwellers have tails as follows: *Indrus brevicaudatus* has practically no tail. *Lepidolemur microdon* has a tail a little over one foot long. *Lemur fulvus* has a tail two feet long. There is no more reason for looking for an external cause as the driving force of evolution to explain the series of tail lengths of these animals than there is for looking for a driving force to explain the numerous series of compounds of organic substances outside of the atoms and particles that make up these compounds.

The tails of monkeys also represent orthogenetic series, from no external tail at all to very long appendages; and it will make no difference how we assume the series to have evolved, whether from short tails to long tails, from long tails to short tails, or from an original medium length tail in both directions, the fact of the series is still present and represents the result which the ultimate cause of the evolutionary movement has brought about, with no reference, directly, to utility or advantage or disadvantage in relation to survival. The Platyrrhines, which are exclusively New World monkeys, have various lengths of tails and some are prehensile and some are not. Some species in the family Cebidae have very short tails but more commonly the tails are long and often prehensile. In the genus *Cebus* the tail, though prehensile, is covered with hair to the tip, being thus a less perfect grasping organ than is the case with those monkeys which have a naked under surface to the prehensile end of the tail. This prehensile tail attains its greatest perfection as a "fifth hand" in the spider monkeys (Ateles), probably the most typically arboreal monkeys of America. Short-tailed American monkeys are species of the genus *Brachyurus*. So these monkey tails form orthogenetic series both in respect to lengths and also in respect to perfection as prehensile organs, from no prehensibility through various degrees to the extremely perfected prehensile tails of the spider monkeys. But these spider monkeys, being of comparatively light weight and slender build, should have the least use for these useful appendages in comparison with various other more robust and heavy arboreal monkeys which have no prehensile tails whatever. The spider monkeys with their long legs and their perfected prehensile tails may be compared with the long-armed agile gibbons, like *Hylobates agilis*, which have no tails at all but which are among the most extreme of arboreal apes.

Now when one studies the Catarrhines, which are exclusively Old World monkeys, he finds no prehensile tails whatever, although they climb about on the trees just as the American monkeys do. These Catarrhines have tails of all sorts of lengths also making typical orthogenetic series from no external tail at all to some with very long tails. Thus *Presbytes melalophos*, the Simpai of Sumatra, has a tail nearly 3 ft. long, while the body of the animal is only about 1½ ft. long. *Cercopithecus diana* of Africa also has a very long tail. *Cercopithecus petaurista*, the White-nose Monkey of Western Africa, has a tail nearly 2 ft. long with a body measuring 15–16 in. *Cynocephalus mormon*, the Mandrill, has a short erect tail. *Cynopithecus niger*, of Celebes, has a very small rudimentary tail. *Macacus inuus*, the Barbary Ape of North Africa, has no external tail, and as stated above, the Agile Gibbon, an extremely active, arboreal species, also has no external tail. If the monkeys tails were originally long, why is there an orthogenetic series of lengths to complete disappearance in these Catarrhines when it is never of use as a grasping organ? Why did some of the American monkeys develop the prehensile ability while the old world monkeys acquired no such mechanism? Would a confirmed teleologist come to the conclusion that the American tropical forests were continuously subject to violent storms which made prehensile tails necessary while the Old World tropics were regions of perpetual calm which thus did not require the tree dwellers to evolve this "fifth" hand to keep from being hurled to earth and untimely death by "unkind mother nature?" The facts must be faced in their generality to see the real absurdity of the teleological explanations, whether Lamarckian or Darwinian. After a certain mechanism has evolved it may be of use to the organism but it could not be of special use until it had evolved to a rather decided stage of perfection. Imagine a poor, Old World monkey trusting for safety to his tail! This notion of adaptation is largely (in this case) a fairy tail. The tails are just not adapted to the trees. But it is remarkable how extremely some biologists are obsessed by the notion of *special adaptation*.

GENERAL CONCLUSION

The fact of orthogenetic series, both accumulative and perfective, plainly shows that the notions of specific adaptation and teleological causation have no scientific basis; since these series have no general correspondence with differential environments nor with any advantage to the individual. It is also clearly evident to the careful student of taxonomy in relation to evolution that the recognition of a perfective principle does not at all require the postulation of an entelechy as elaborated by Driesch and others. But the recognition of the orthogenetic series and of the perfective series as a result of the perfective principle in the organic kingdom does require us to recognize an internal creative principle which is just as evident and unescapable as the fact of the general atomic series and the complicated molecule systems of the chemist.

In addition to the evidence from orthogenetic series, further knowledge of the nature of the evolutionary process may be obtained from a study of the constancy attained at the limits of the series. This unchangeableness is well illustrated by the 4,000 species of grasses all of which have attained the two-ranked condition of the leaves and the unilocular ovulary. Both of these characteristics represent the possible determinate evolutionary limit. The same is true for the ten to fifteen thousand species of the subfamily Orchidatae, practically all of which have two-ranked leaves and also have a unilocular ovulary and a single stamen always occupying the same position in the flower. This constancy of the evolved structures which have attained the limit of the orthogenetic series shows how far from the mark are those speculations which see in the abnormal mutations caused by X-rays, radium, ultra-violet light, cosmic rays, etc., the fundamental cause of the evolution of the taxonomic system of plants and animals. The grasses and orchids and other such large culmination groups have been bombarded for millions of years by cosmic and other rays but the fundamental potentialities remain unchanged, although an enormous amount of subordinate evolution and speciation has been going on.

In recognizing the existence of an *internal* creative principle, science comes to its limit. The next step in causative reasoning, as to what is the ultimate cause of this orthogenetic, progressive, perfective principle, is a question of theistic philosophy and belongs to the domain of the philosopher rather than the scientist. An anarchistic philosophy is definitely contradicted by the facts of the orderly taxonomic system in general and by the presence of the perfective, orthogenetic series in particular. The biologist, however, can recognize the fact of a *universal design* in nature as a scientific discipline and the remarkable success which the fundamental evolutionary activities have brought about in the *balance of nature*, which not only permits thousands of the most diverse types and species to come into existence but also allows, in spite of the struggle for life, endless numbers of species to continue successfully in the narrow shell of the earth's surface for millions of years.

The examples of orthogenetic series discussed in this paper, and which could be multiplied indefinitely, show again that evolution is intrinsic rather than extrinsic, kinetic rather than static; progressive, orthogenetic, and perfective rather than haphazard; and finally determinative in many of its characteristic movements.

Sterilization

This volume is a report of a special committee of the American Neurological Association appointed to study the question of Eugenical Sterilization from a medico-legal standpoint. Four of the authors are physicians, the fifth being a consultant in Genetics (Keeler). The book opens with a short history of sterilization, followed by a rather detailed summary of the laws of the various states and of some foreign countries. The main arguments for sterilization are reviewed, some of them being severely criticized by the authors. The data on the inheritance of various mental conditions are critically reviewed. A very short chapter on crime is included. The committee recommends that sterilization laws in the United States should be voluntary rather than compulsory, that they should apply to mental defectives in private institutions and at large in the state as well as to those in state institutions, that they should be administered by boards composed of persons with special training who are legally protected by statute, and that such laws should apply only to selected cases in the following conditions: Huntington's chorea and certain other disabling degenerative diseases recognized to be hereditary, feeblemindedness of familial type, dementia praecox, manic-depressive psychosis and epilepsy. The committee warns against the sterilization of normal persons for purposes of preventing the appearance in their descendants of undesirable mental traits, it frowns on the use of sterilization for immorality or character defect, it urges that environment be not lost sight of as important in the production of all traits, and finally the committee urges further co-ordinated research along these various lines. The style of the book is somewhat rambling and not completely unbiased, but the volume is nevertheless worthwhile, chiefly for its critical review of the literature.—L. H. S.

Eugenical Sterilization, by a Committee of the American Neurological Association. 211 pp. New York, The Macmillan Co., 1936. $3.00.

ADDITIONAL NOTES ON ARGULUS TRILINEATUS (WILSON)

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The female of this species was described by Wilson (1904) from specimens collected on goldfish in Georgia and Kentucky. Cockerell later identified them in Colorado and suggested that they might be closely related to *Argulus coregoni*. Guberlet described the males for the first time in 1928 from specimens taken on goldfish in Washington and California. Since that time they have been recognized in a great many places over the country, so that the distribution is quite extensive.

The present specimens were taken from goldfish, *Carassius auratus*, at Natchitoches, Louisiana. These have been compared with types 56568 loaned by the U. S. National Museum, and with *A. coregoni* sent by the British National Museum. Dr. Zacwilichowski of Jagelon University, Krakow, Poland, was kind enough to send female specimens of *Argulus foliaceous*, while Dr. Schellenberg of "Der Zoologisches Museum der Universität, Berlin, Germany, sent both males and females for comparative purposes. There has been no opportunity to examine the type for *A. trilineatus* (Wilson).

The one significant feature overlooked in the original description that sets the species apart from all others in America is that the ribs on the dorsal side of the carapace are forked as in the European species. Guberlet showed this in figure 1 of his monograph, but failed to mention it. Wilson (1903) stated that it is one of the characteristics distinguishing the European species since none of the American species which he had observed had such a modification.

To be sure the branches are not readily apparent on some specimens, but are very obvious on others. They are found on the specimens from the National Museum, as well as those from Louisiana. One can make them distinguishable by staining lightly with methylene blue. After it has once been called to attention, one can readily see, from the offset of the rib in the region of the base of the antennae, that the shape is such as to suggest the presence of a branch. This feature is no more apparent on some specimens of *A. foliaceous* than on the American species. At the same time these ribs are definitely bowed inward between the eye and sucker regions and outward around the brain rather than nearly parallel as previously described. Figure 1 shows all of these characteristics.

A perusal of the European literature from 1800 on would lead one to suspect that *A. trilineatus* might be exactly like *A. foliaceous* except for size. An examination of the description and figures by Claus (1875), which seem to be the most complete, reveals that his description follows the American species almost identically. In his paper, figure 22 of the respiratory areas is identical with our species, figure 25 of the dorsal ribs is the same, figure 20 shows the antennae exactly alike, while figure 26 has four leaves between the ribs of the sucker and five to six plates in each of these ribs with the same shape as the local species. His figure 44 is a drawing of the accessory sex organs of the last two pairs of legs which might have been taken from American specimens. Even the spines on the comb and second and third segments of the second maxillipeds, which are different on each of the European species, are similar, so that all details described and figured are alike for *A. foliaceous* and *A. trilineatus*.

Although Claus has drawn a "peg" identical to that of the American species, the European specimens at hand are somewhat different. Figures 2 and 3 are drawings of the organs from the two; figure 2 is that of the American form. They do show a similarity, but are not as much alike as shown by him. On the German specimens at hand this structure is much less chitinous and does not become as spatulate. This would seem to indicate that both species have changed somewhat.

No mention was made in any of the European literature of the accessory organs on the second pair of legs of the male. Wilson (1904), in his description of *A. foliaceous*, states, ". . . Abdomen is the male considerably elongated, but no copulatory organs except the regular peg and semen vesicle. . . ." An examination of specimens shows that there is an accessory organ on these legs such as that shown in figure 4.[1] There is considerable difference between this and figure 5, which is the same organ on *A. trilineatus*. This structure is almost identical with that of *A. coregoni*.

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[1] A paper by Wagler (1935) was called to my attention since gathering this data. It has a good figure of the organ (Fig. E, p. 8).

Communications with two European authorities state that there is confusion in the identification of the two native species. If they do actually intergrade, as one would be led to believe, it is very possible that the American form is derived from European stock not so far back. Such is indicated by the fact that they are found only on goldfish in this country, most of which are of European origin, and because it has some of the distinguishing marks of both of the species found there.

There are certain other features of *A. trilineatus* which have either been missed or not adequately described. Chief among these is the structure of the second antennae. Wilson definitely states that there are two distal segments (1904, p. 652 and fig. 26) and Guberlet says, "The basal joint of the second antennae is longer and thicker than the two distal joints." On all of the specimens examined, including those from the Museum, there are three distal segments as shown in figure 6. The apparent oblique direction of these segments that has been noted for some specimens, is wholly due to the fact that they are attached on the posterior edge of the basal segments and the direction is dependent upon the way they are flexed when the animal is killed. It is variable from specimen to specimen and probably is of no specific value.

On the first maxillipeds the ribs are composed of a series of plates similar to figure 7. These increase in size from the outer to the inner edge and number five or six with an additional basal plate supporting them on the inner rim. The number is variable even in the same appendage on some animals. The number of leaves along the outer edge of the disc, counting between the ribs, varies from five to eight, but five or six is the common number.

The respiratory areas are not exactly as figured by Wilson. They are somewhat narrower at the top than at the bottom with a depression on the side toward the body, so that the appearance is almost reniform. The anterior respiratory area is egg-shaped with the point toward the body and between the sucker and posterior respiratory area. These are shown in figure 8.

The accessory organs of the male have already been described. Martin (1932) made observations on the copulating animals and found that they are used for clasping rather than for the actual transfer of the sperms as some of the earlier authors have intimated. From the shape of the armature of the organs figured in the literature, and from the fact that the genital openings are nowhere near them, it is easy to visualize the possibility that such is the case.

There seems to be no structure such as the "flattened bladelike" projection on the anterior border of the second pair of legs as described by Guberlet. The nearest approach to such a formation occurs in many instances where the musculature has pulled away from the exoskeleton on mounted specimens, but this is not confined to the second legs alone. There is a flat plate-like area between the second and third legs.

The pigment spots, from which the American species gets its name, are also found on *A. foliaceous* and are arranged in two double rows, one on either side of the abdomen. These are decidedly a more distinct characteristic of the female than of the male. The male is characterized by the large amount of pigment in the lateral canals extending out into the wings of the carapace on either side and dividing into two branches, one running forward and the other backward and dividing into numerous smaller lateral branches extending toward the outer edges. There are other species which have pigment along these canals. It is also found on the female but is not nearly so prominent.

Certain characters seem to be variable from one individual to the next. The carapace may reach the abdomen on some specimens and extend only to the third legs on others. There is some variation in the proportions according to the individual. There is variation in the size and length of the antennae. The number of plates in the ribs of the suckers may be different as well as the number of leaves between the ribs. On some specimens there is a definite cross rib between the joints of the dorsal ribs behind the brain, while on others it is not noticeable, but may be represented by a fold or be entirely lacking.

The striking similarity between *A. trilineatus* and *A. foliaceous*, including the branching of the dorsal ribs, definitely marks the American species as being of European origin. The shape of the peg, which is one of the specific characters, is similar. Such small details as the setae on the second maxillipeds, the number of plates in the ribs of the sucker, and the number of leaves between them are almost identical. The European species has a slightly different type of armature on the second legs in the male and lacks the flat protuberance between the second and third legs which is so characteristic of the American form. The females of the two species are alike. If there is as much variation within the European species as is shown by Claus' figures and as compared with the specimens examined, then there is less difference between the species of the two continents than there is between the two from Europe.

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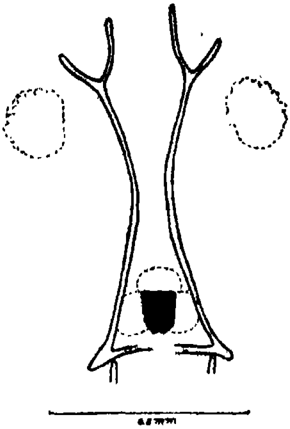
EXPLANATION OF PLATE

Fig. 1.	Dorsal ribs of *A. trilineatus.*
Fig. 2.	Accessory appendage of fourth legs on male.
Fig. 3.	Similar appendage from *A.* foliaceous.
Fig. 4.	Accessory appendage of second legs of male.
Fig. 5.	Similar appendage on *A. trilineatus.*
Fig. 6.	Antennae of *A. trilineatus.*
Fig. 7.	Ribs of the sucking disc.
Fig. 8.	Respiratory areas.

Argulus trilineatus
O. Lloyd Meehean

PLATE I



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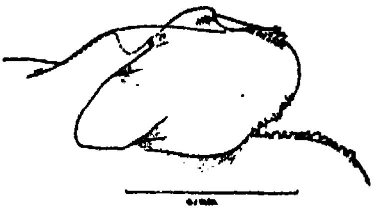

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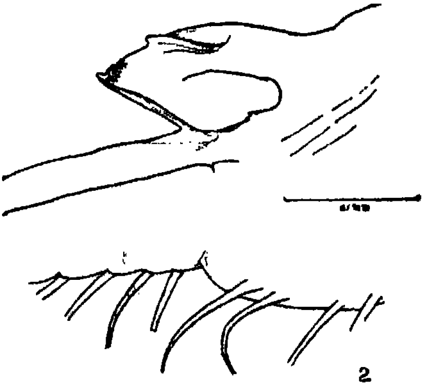

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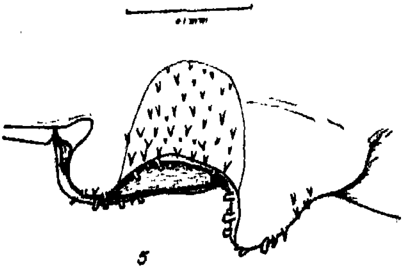

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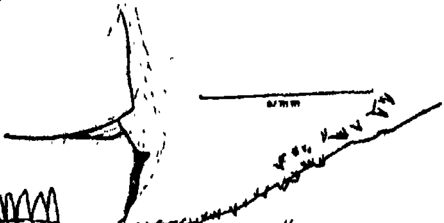

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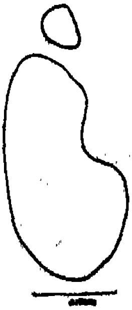

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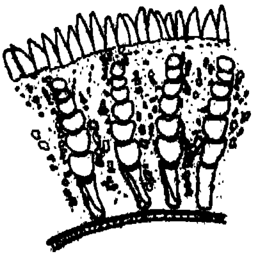

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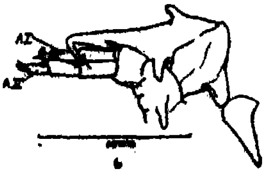

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BOOK NOTICES

Nineteenth Century Eugenics

In this book (a partial autobiography) a successful national leader of mature years reviews his own boyhood in the Oneida Community, a communistic venture in New York state in the four decades that embraced the middle of the nineteenth century. The eugenicist of today finds much to praise in this communal effort. Selective mating was practiced through "complex marriage" and children were brought up, not by their parents, but in a series of carefully supervised and graded departments. A strong religious motive pervaded this group and proved both the bond of early union and the basis of later dissention. Outside pressure completed the schism in the early 1880's. Much of this book treats of routine narrative that might be written of the life of any boy up to sixteen years, the story of the Community being interwoven into this narrative. This communal project was noble effort of a sincere people, an effort that deserved better success and wider emulation.—R. A. HEFNER.

My Father's House, an Oneida Boyhood, by Pierrepont Noyes. New York City, Farrar & Rinehart, 1937. $3.50.

Georg Wilhelm Steller

To most biologists the name of Steller is associated with Steller's jay and Steller's sea cow. It is thus a revelation to learn that this German naturalist in the service of Russia 200 years ago was a physician and a botanist and made his famous voyage to Alaska as a mineralogist with Bering's expedition in 1741. The harrowing tale of this expedition by sail in Arctic waters is best summarized by the fact that disease, mainly scurvy, claimed the lives of 31 men from a total of 78 in the exploring party and crew, Bering himself being one of the victims. Before and after the Alaskan expedition, Steller made natural history surveys in eastern Siberia, around Lake Baikal, the Kamtchatka peninsula, and along the great river courses to the North. He made long sledge journeys in the rigorous winters, handicapped less by climate than by the suspicions and intrigues of old Russia in the troublesome period that followed Peter the Great. Suspected of treason, Steller was arrested in Russia, transported to Siberia, acquitted, and died of a fever at the age of 36 while returning to Russia.

The data collected for this book was accumulated by the author over a period of more than 50 years. The book is more than an exhaustive biography of a great naturalist; it is a model of meticulous detail in biographical writing.

—R. A. HEFNER.

Georg Wilhelm Steller, the Pioneer of Alaskan Natural History, by Leonard Stejneger. 623 pp. Cambridge, Harvard University Press, 1936. $6.00.

Man and His World

This book is the successor to "The Nature of the World and of Man." It is extensively rewritten and brought up to date. The authors of the various chapters are professors (in one case a former professor) at the University of Chicago. The arrangement and material are improved over the former book, and the new volume seems admirably adapted to an orientation course. Certainly the material contained therein is basic and fundamental to a well-rounded education. Some of the chapters are extremely stimulating and fairly self-explanatory; others, such as the one on particles and waves, seem beyond the freshman level and will require much "teaching." On the whole the book is a fine and successful attempt to provide a broad overview of man and his world.—L. H. S.

The World and Man as Science Sees Them, edited by Forest Ray Moulton. xix+533 pages. Chicago, The University of Chicago Press, 1937. Text Edition, $3.00.

SOME CLADONIAE FROM SOUTHWESTERN OHIO

CLADONIAE FROM CLERMONT, BROWN, AND ADAMS COUNTIES

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University of Cincinnati

At the present time there are few published records for species of Cladonia in southwestern Ohio. Dr. Bruce Fink's many papers on Cladonia species include general distribution data rather than locality records, so that while he no doubt studied plants from the southwestern part of the state his published reports do not include such. Mr. Thomas G. Lea[1] listed a number of species but his records are from Hamilton County (Cincinnati) or Northern Kentucky and are not included in this report.

The present paper includes collections from Clermont, Brown and Adams Counties. They are east of Hamilton County (Cincinnati) in the order named, and all of them border on the Ohio River. Except for the hilly areas along the Ohio and its tributaries, Clermont and Brown Counties are mostly made up of poorly drained upland flats of glacial till, where pin oak, swamp white oak, and sweet gum are conspicuous trees. (Much of the area has been cleared and is now under cultivation.) Most of Adams County is unglaciated. It is primarily an area of high hills and narrow valleys. Limestones and shales are the principle underlying rocks though sandstone is occasionally found at the tops of some of the higher ridges. The forests are prevailingly of the deciduous type though occasional pine areas occur.

The Cladonias are most abundant in old abandoned fields in both Clermont and Brown Counties; in Adams County they occur in great abundance along old wagon roads, in open pine woods, and on ridge tops, as well as in the grassy meadows.

The writer wishes to express her sincere appreciation in acknowledgment of the kindness of Dr. A. W. Evans, of Yale University, who has determined the material, and given helpful criticism in the preparation of this paper. Some of the specimens were sent by Dr. Evans to Dr. Sandstede, of Bad Zwischenahan, Oldenburg, and his determinations and comments are noted under the specimens in question.

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[1] Lea, Thos. G. Catalogue of the plants, native and naturalized, collected in the vicinity of Cincinnati, Ohio, during the years 1834–1844, by Thos. G. Lea, Philadelphia, 1849.

The specimens in the list which follows are arranged according to the classification of Vainio[2] which has been adopted by most of the recent writers on Cladonia. Unless otherwise noted the specimens were collected by the writer. The specimens are in the herbarium of Yale University, with a duplicate set in the herbarium of the University of Cincinnati.

Subgenus **Cladina**

Cladonia rangiferina (L.) Web. On earth in fields. The species is rare in the southwestern past of the state, and most of the specimens which have been locally referred to this species, are found, on examination, to be *C. tenuis*, which is very common. The only known station contains four or five clumps six to eight inches in diameter. Brown Co.: Quinn School near Vera Cruz.

Cladonia tenuis (Floerke) Harm. On soil in open woods and fields. This is the only abundant species of the subgenus Cladina in southwestern Ohio. Adams Co.: Beaver Pond; Lynx. Brown Co.: Quinn School near Vera Cruz; Vera Cruz (Miss Braun).

Cladonia tenuis f. *setigera* Sandst. Adams Co.: Mineral Springs. Brown Co.: Quinn School near Vera Cruz. Clermont Co.: Nicholsville (Miss Braun).

Subgenus **Pycnothelia**

Cladonia papillaria (Ehrh.) Hoffm. On clay soil, banks, hillsides, and open fields. Not common. The species is represented by the three forms listed below.

Cladonia papillaria f. *molariformis* (Hoffm.) Schaer. Adams Co.: near Beaver Pond; Mineral Springs. Brown Co.: Quinn School near Vera Cruz (Dowd).

Cladonia papillaria f. *papillosa* Fr. Adams Co.: Mineral Springs.

Cladonia papillaria f. *prolifera* (Wallr.) Schaer. Adams Co.: Beaver Pond.

Subgenus **Cenomyce**

Section 1. **Cocciferae**

Subsection 1. **Subglaucescentes**

Cladonia bacillaris (Ach.) Nyl. On decaying logs and stumps. Not frequent. Adams Co.: Beaver Pond; Mineral Springs. Brown Co.: Quinn School near Vera Cruz.

Cladonia didyma (Fée) Vainio. On dry, decaying logs. Not common. Adams Co.: Mineral Springs. Dr. Evans says of this specimen that it is probably the form *subacuta* but that it is not distinctive.

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[2] Vainio, E. Monographia *Cladoniarum universalis*. Pars prima. Acta Soc. Fauna et Flora Fennica 4: 1–510. 1887. Pars secunda. Ibid. 10: 1–499. 1894. Pars tertia. Ibid. 14: 1–268. 1897.

Cladonia didyma f. *squamulosa* Robbins. Adams Co.: Mineral Springs.

Subsection 2. **Stramineo-flavidae**

Cladonia cristatella Tuck. On old wood, bases of trees, and soil in fields and open woods. Widely distributed. Adams Co.: Beaver Pond. Brown Co.: Quinn School near Vera Cruz.

Cladonia cristatella f. *Beauvoisii* (Del.) Vainio. Adams Co.: Beaver Pond; Lynx; Mineral Springs. Brown Co.: Quinn School near Vera Cruz; Vera Cruz (Miss Braun).

Cladonia cristatella f. *vestita* Tuck. Adams Co.: Beaver Pond; Lynx; Mineral Springs. Brown Co.: Quinn School near Vera Cruz; Vera Cruz (Miss Braun).

Section 2. **Ochrophaeae**

Subsection 1. **Unciales**

Cladonia uncialis (L.) Web. On soil in open hillside woods. Rare. Clermont Co.: Nicholsville (Miss Braun).

Cladonia caroliniana (Schwein.) Tuck. On earth in open woods in hilly localities. Rare. The species is represented only by one form.

Cladonia caroliniana f. *dilatata* Evans. Adams Co.: Mineral Springs.

Subsection 2. **Chasmariae**

Group 1. **Microphyllae**

Cladonia furcata (Huds.) Schrad. On soil in fields and open woods, sometimes on rocks. The species and its forms are very common throughout the area. One variety and three forms have been collected. Brown Co.: Quinn School near Vera Cruz.

Cladonia furcata var. *racemosa* (Hoffm.) Floerke. Adams Co.: Beaver Pond; Mineral Springs; Lynx. Brown Co.: Quinn School near Vera Cruz. Clermont Co.: Milford.

Cladonia furcata var. *racemosa* f. *corymbosa* (Ach.) Vainio. Adams Co.: Bundle Run (Miss Braun); Mineral Springs; Lynx. Brown Co.: Quinn School near Vera Cruz; Vera Cruz (Miss Braun).

Cladonia furcata var. *racemosa* f. *squamulifera* Sandst. Adams Co.: Beaver Pond. Brown Co.: Quinn School near Vera Cruz; Vera Cruz (Miss Braun). Clermont Co.: Cabin Run (Miss Braun).

Cladonia squamosa (Scop.) Hoffm. On soil in open woods. The species is not abundant in the area. Clermont Co.: Nicholsville (Miss Braun).

Cladonia squamosa f. *levicorticata* Sandst. Adams Co.: Mineral Springs.

Cladonia delicata (Ehrh.) Floerke. On decayed oak stumps and logs. Common locally. The specimens all belong to one form.

Cladonia delicata f. *quercina* (Pers.) Vainio. Adams Co.: Beaver Pond; Mineral Springs.

Cladonia caespiticia (Pers.) Floerke. On soil, on banks, in fields, and in open woods. Not uncommon locally. Adams Co.: Beaver Pond; Mineral Springs.

Group 2. **Megaphyllae**

Cladonia apodocarpa Robbins. On earth in abandoned fields. Frequent. Adams Co.: Beaver Pond; Lynx. Brown Co.: Quinn School nera Vera Cruz.

Subsection 3. **Clausae**

Group 1. **Podostelides**

Cladonia mitrula Tuck. On soil in fields and on banks, sometimes over tree roots. Very common. Our specimens represent two forms.

Cladonia mitrula f. *imbricatula* (Nyl.) Vainio. Adams Co.: Beaver Pond; Lynx. Clermont Co.: Bethel (Twichel); near Nicholsville.

Cladonia mitrula f. *pallida* Robbins. Brown Co.: Vera Cruz (Miss Braun).

Cladonia clavulifera Vainio. On earth in abandoned fields. Not common. Brown Co.: Quinn School near Vera Cruz. Determined by Dr. Sandstede. Clermont Co.: Nicholsville (Miss Braun).

Cladonia clavulifera f. *nudicaulis* Evans. Brown Co.: Quinn School near Vera Cruz.

Cladonia subcariosa Nyl. On earth in fields, on roadside banks, and in open woods. Very abundant. Adams Co.: Beaver Pond. Clermont Co.: Nicholsville (Miss Braun).

Cladonia subcariosa f. *evoluta* Vainio. Adams Co.: Beaver Pond. Brown Co.: Quinn School near Vera Cruz (Miss Braun).

Cladonia subcariosa f. *squamulosa* Robbins. Adams Co.: Beaver Pond. Brown Co.: Quinn School near Vera Cruz; Vera Cruz (Miss Braun).

Cladonia brevis Sandst. On soil bank. The specimen is represented by *thallus* only. It was determined by Dr. Sandstede. Adams Co.: Beaver Pond.

Group 2. **Thallostelides**

Cladonia gracilis (L.) Willd. The species is rare in this region and is represented only by a variety and a form.

Cladonia gracilis var. *dilatata* (Hoffm.) Vainio. Brown Co.: Quinn School near Vera Cruz.

Cladonia gracilis var. *dilatata* f. *dilacerata* (Floerke) Vainio. Adams Co.: Beaver Pond.

Cladonia verticillata (Hoffm.) Schaer. On soil on banks and in fields. Very abundant. Brown Co.: Quinn School near Vera Cruz.

Cladonia verticillata f. *apoticta* (Ach.) Vainio. Adams Co.: Beaver Pond. Brown Co.: Vera Cruz (Miss Braun). Clermont Co.: Nicholsville (Miss Braun).

Cladonia verticillata f. *evoluta* (Th. Fr.) Stein. Adams Co.: Beaver Pond; Lynx. Brown Co.: Quinn School near Vera Cruz; Vera Cruz (Miss Braun). Clermont Co.: Bethel (Twichel).

Cladonia verticillata f. *phyllocephala* (Flot.) Oliv. Adams Co.: Beaver Pond; Lynx. Brown Co.: Vera Cruz (Miss Braun).

Cladonia pyxidata (L.) Hoffm. On soil, hillside under red cedar. Rare. The species is represented by one variety.

Cladonia pyxidata var. *neglecta* (Floerke) Mass. Clermont Co.: Nicholsville (Miss Braun).

Cladonia chlorophaea (Floerke) Spreng. On soil in fields, open woods, and banks, sometimes on the bases of trees. Common. Brown Co.: Quinn School near Vera Cruz.

Cladonia chlorophaea var. *intermedia* Sandst. Adams Co.: Lynx. The specimen was determined by Dr. Sandstede.

Cladonia grayi Merrill. On soil in fields and open woods. Frequent. Most of the specimens have been verified by Dr. Sandstede. Adams Co.: Mineral Springs; Lynx. Brown Co.: Vera Cruz (Miss Braun). Clermont Co.: Nicholsville (Miss Braun).

Cladonia fimbriata (L.) Fr. On soil in abandoned field. Rare. Brown Co.: Quinn School near Vera Cruz.

Cladonia nemoxyna (Ach.) Nyl. On soil in abandoned field. Rare. Dr. Sandstede has given a provisional name *C. subnemoxyna* to all those forms originally included in *C. nemoxyna* which show a negative reaction with paraphenylendiamin. This negative reaction is characteristic of our specimen. The restricted *C. nemoxyna* always gives a positive reaction. Dr. Evans says that apparently the latter is much more common in North America. Brown Co.: Quinn School near Vera Cruz.

Cladonia coniocraea (Floerke) Spreng. On soil in fields and open woods. Common. Adams Co.: Mineral Springs; Beaver Pond.

Cladonia coniocrea f. *ceratodes* (Floerke) Dalla Torre & Sarnth. Adams Co.: Beaver Pond; Lynx; Mineral Springs. Brown Co.: Vera Cruz (Miss Braun). Some of the specimens have been examined by Dr. Sandstede.

Cladonia coniocrea f. *robustior* (Harm.) Sandst. Adams Co.: Beaver Pond; Mineral Springs. Both of these determinations were verified by Dr. Sandstede.

Cladonia coniocrea f. *truncata* (Floerke) Dalla Torre & Sarnth. Adams Co.: Beaver Pond; Mineral Springs; Lynx. Brown Co.: Vera Cruz (Miss Braun).

Cladonia borbonica (Del.) Nyl. On logs, soil banks and thin soil over rocks. Frequent. Brown Co.: Quinn School near Vera Cruz.

Cladonia borbonica f. cylindrica Evans. Adams Co.: Beaver Pond. Brown Co.: Quinn School near Vera Cruz; Vera Cruz (Miss Braun). Clermont Co.: Branch Hill (Cooke); Milford.

Cladonia pityrea (Floerke) Fr. On soil and old wood. Not common. The species is represented by one variation.

Cladonia pityrea var. *Zwackhii* f. *subacuta* Vainio. Adams Co.: Mineral Springs. Brown Co.: Vera Cruz (Miss Braun).

Group 5. **Foliosae**

Cladonia strepsilis (Ach.) Vainio. On soil in fields and open woods. Frequent. Brown Co.: Quinn School near Vera Cruz.

Cladonia strepsilis f. *coralloidea* (Ach.) Vainio. Adams Co.: Beaver Pond (Fahnestock). Brown Co.: Quinn School near Vera Cruz.

Group 4. **Ochroleucae**

Cladonia piedmontensis Merrill. On soil in fields and open woods. Frequent. The species is represented locally by three forms.

Cladonia piedmontensis f. *lepidifera* (Vainio) Robbins. Brown Co.: Quinn School near Vera Cruz. Clermont Co.: Nicholsville (Miss Braun).

Cladonia piedmontensis f. *squamulosa* Robbins. Adams Co.: Beaver Pond. Brown Co.: Vera Cruz (Miss Braun).

Cladonia piedmontensis f. *squamosissima* Robbins. Brown Co.: Vera Cruz (Miss Braun).

Twins

The eagerly awaited comprehensive report of Professor Newman's studies of twins is at last at hand, and a very fine treatise it is. Newman has enlisted the aid of a psychologist and of a statistician in evaluating the data, and the resulting book is the co-ordinated report of the three men. The data presented include careful physical and mental measurements of fifty pairs of identical twins reared together, fifty pairs of like-sexed fraternal twins reared together, and nineteen pairs (twenty including Muller's case) of identical twins reared apart. The data are presented in full, with complete statistical analyses. The authors' interpretations are carefully and dispassionately presented, with clear distinctions between factual and theoretical conclusions. A strong case is made for pre-natal differences in the environments of identical twins, involving unequal blood exchange between twin fetuses, and the asymmetry mechanism, and resulting in certain differences between identical twins reared together. The authors agree that some characteristics are more susceptible to environmental differences than are others; also that as more research becomes available on the complex of genetic and environmental factors that interact in the development of individuals, more and more problems appear, none of which has an easy or general solution. This book belongs on the "must" list of every biologist and psychologist.—L. H. S.

Twins: A Study of Heredity and Environment, by H. H. Newman, F. N. Freeman, and K. J. Holzinger. xvi+369 pp. Chicago, University of Chicago Press, 1937. $4.00.

Haploids and Polyploids

This pamphlet contains a concise summary of the occurrence of haploids and polyploids in flowering plants. Polyploidy in somatic cells, polyploid gametes and polyploidy as the result of hybridization are treated separately. The plants in which polyploidy is known to occur are listed, and the causes, both natural and artificial, are briefly discussed. There is also an extensive bibliography of the literature on haploids and polyploids. It is a valuable reference for anyone interested in polyploidy.—D. C. Rife.

The Experimental Production of Haploids and Polyploids. 27 pp. Imperial Bureau of Plant Genetics, School of Agriculture, Cambridge, England, 1936.

NEW SOUTHWESTERN BUPRESTIDAE AND CERAMBYCIDAE WITH NOTES

JOSEF N. KNULL,

The Ohio State University

Acmaeodera gibbula Lec. and **A. alicia** Fall.

Reared from the dead branches of palo verde (*Cercidium torreyanum* Sarg.) collected at Tucson, Ariz.

Acmaeodera yumae n. sp.

Robust, depressed; head, pronotum, ventral surface and legs bronze, elytra yellow, each elytron margined with a narrow dark border on all sides, an irregular dark stripe extending from base, over umbone, to near apex; head, pronotum, ventral surface and legs clothed with long pubescence which partly obscures the surface.

Head convex, no trace of median depression; surface coarsely punctured; eyes large, finely granulate; antennae serrate beginning with the fifth joint.

Pronotum wider than long, widest back of middle, wider at base than at apex, sides broadly rounded from base to apex; lateral margin not visible from above; anterior margin sinuate, median lobe broadly rounded; basal margin truncate; disk convex, a shallow depression in front of region of scutellum; surface coarsely confluently punctured.

Elytra about same width as pronotum; sides nearly parallel at base, constricted in front of middle, broadly rounded to obtusely rounded apices; side margins serrulate back of middle; disk convex, umbone prominent; surface with coarsely punctured striae arranged in pairs, every other interval wider, punctures of intervals fine, a long fine hair arising from each interval puncture.

Abdomen beneath finely punctured, last ventral segment with a rounded subapical ridge. Front margin of prosternum retracted, sides not reaching the front angles, a dentiform prominence on each side of middle.

Length, 11 mm.; width, 3.5 mm.

Holotype labeled Yuma, Ariz., April 11, 1933, E. D. Ball, collector, in the collection of the writer.

According to Fall's key[1] this species would come in the Sinuata group next to *A. lanata* Horn. The dense vestiture of the ventral surface together with the markings of the elytra will serve to separate this species from the closely related forms.

Acmaeodera constricticollis n. sp.

Form robust; elongate, head, pronotum and ventral surface bronze, elytra yellow with numerous irregular small dark spots.

Head convex, no trace of median depression, surface with large shallow punctures, densely clothed with long white pubescence; eyes large, finely granulate; antennae serrate beginning with the fifth joint.

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[1] H. C. Fall. Jour. N. Y. Ent. Soc., VIII, pp. 1–37. 1899.

Pronotum wider than long, widest back of middle, wider at base than at apex; sides in front oblique to constricted apex, broadly rounded to basal constriction; lateral margin not visible from above; anterior margin sinuate, median lobe prominent; basal margin broadly emarginate; disk convex, slight trace of median depression; surface with punctures coarse in front of scutellum, large shallow punctures in front and toward sides, clothed with long pubescence, white scales at sides.

Elytra broader than widest part of pronotum; side margins rounded in front to constriction in front of middle, then broadly rounded to obtusely rounded apices; lateral margins serrulate back of middle; disk convex, umbone prominent; surface with strial punctures confluent, punctures of interspaces small, a short, recumbent hair arising from each interspace puncture.

Ventral surface and legs clothed with white scales which obscure most of the sculpture. Abdomen beneath densely punctured, last ventral segment without a subapical plate. Front margin of prosternum straight, sides not reaching the front angles.

Length, 8.8 mm.; width, 2.8 mm.

Holotype labeled Phoenix, Ariz., July 15, 1936, E. D. Ball, collector, in the collection of the writer.

This species belongs to the Truncate group and would come next to *A. cribricollis* Horn. However, the form of the prothorax will separate the two.

Tyndaris balli n. sp.

(Fig. 1)

Female—Form robust; head, thorax and ventral surface bronze, each elytron with edges piceous varying to dark brown with a bronze luster, inner portion which occupies most of the elytra yellow.

Head convex, no trace of median depression; surface reticulate, clothed with scale-like recumbent pubescence; eyes finely granulate; antennae reaching to about middle of pronotum when laid along side margin, serrate from the fourth joint.

Pronotum wider than long, widest back of middle, narrower at apex than at base; disk moderately convex, a deep depression on each side at base, base longitudinally rugose along margin; lateral margin inferior in front; sides broadly rounded from base to apex; anterior margin sinuate, slightly lobed; basal margin nearly straight; surface reticulate clothed with broad spatulate scales. Scutellum triangular.

Elytra at base not as wide as widest part of pronotum, metasternal episterna covered by elytra; sides constricted at base, and in front of middle, broadly rounded posteriorly to rounded apices, side margins serrulate from about middle; disk flattened, umbone prominent; striate, striae coarsely punctured, interspaces containing spatulate recumbent pubescence.

Abdomen densely clothed with spatulate white scales, last abdominal segment rounded, not spiniform.

Tarsi slender, not cordiform, claws each with a blunt basal tooth.

Length, 5.3 mm.; width, 2.3 mm.

Male—Differs from female by the longer antennae and broader outer joints.

Described from specimens collected at Congress Junction, Ariz., June 19, 1935, by Dr. E. D. Ball, in whose honor the species is named. Holotype female, allotype and paratypes in the writer's collection. Paratypes in collection of the University of Tucson and The Ohio State University.

This species agrees with the genus *Tyndaris* better than with *Paratyndaris* although the form of the tarsi could apply to the latter genus. I have placed it provisionally in the former genus.

Hesperorhipis mirabilis n. sp.

(Fig. 2)

Ventral surface dark blue becoming more brilliant at ventral portion of prothorax, head and pronotum brilliant metallic green, each elytron with a large basal triangular metallic green area extending along suture, a transverse curved white band extending from costal margin to suture and narrowly extending along suture, rest of elytra dark blue.

Male—Head convex, slight indication of median depression; surface asperate on front, reticulate on vertex; eyes small, finely granulate; antennae dull testaceous, extending about one-third the length of the elytra when laid along the side of the pronotum, flabellate, quite similar to that of *Xenorhipis brendeli* Lec. figured by Horn,[2] rami beginning at the third joint; last joint of maxillary palpus ovate, apex rounded.

Pronotum wider than long; anterior margin sinuate, median lobe broadly rounded; basal margin slightly sinuate at middle of each elytron; disk convex, without depressions, or raised areas; lateral margin inferior in front, present in basal third only; sides nearly parallel in middle, acutely rounded in front and broadly rounded in back; surface reticulate. Scutellum dark blue, granulate.

Elytra with base not as wide as base of pronotum, not covering the abdomen but extending to first abdominal segment only, twice as long as wide; sides nearly parallel in front, constricted back of middle, broadly rounded posteriorly to acutely rounded apices, sutural margin sinuate back of middle; surface rugose, rugae less evident in white area; under wings visible, tips extending to beyond end of abdomen.

Abdomen beneath asperately punctate; sides of metasternum with a large hairy depression, or excavation. Basal joint of hind tarsus equal in length to the three following joints.

Length, 3.5 mm.; width, 1.2 mm.

Described from male specimens taken on the foliage of one of the cat's claws (*Acacia* sp.) in the Gila Mountains, Ariz., on July 7 to 9, 1936, by the author. Holotype and paratypes in the writer's collection.

This species is closely related to *H. albofasciatus* Fall. However, the excavation on the side of the metasternum will serve to separate it from his species. Professor Fall informs me that the type is lacking this depression.

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[2] A. H. Horn. Trans. Amer. Ent. Soc., 10, p. 165. 1882.

Agrilus cercidii n. sp.

Male—Form small, narrow, elongate, subcylindrical, shining, piceous; each elytron with three patches of white pubescence along suture, one in basal depression, an elongate patch at middle and one on apical third.

Head strongly convex with greenish tinge, without median depression; surface finely granulose, pubescence sparse; antennae short, reaching to about middle of pronotum when laid along side margin, serrate from the fifth joint, outer joints wider than long.

Pronotum slightly wider than long, narrower at base than at apex, side margins feebly arcuate; when viewed from the side the marginal and submarginal carinae are separated for their entire length; anterior margin sinuate, median lobe broadly rounded; basal margin strongly emarginate at middle of each elytron, disk convex, without depressions, prehumeral carinae lacking; surface obsoletely granulose, obliquely rugose, the rugae widely separated, pubescence sparse. Scutellum triangular, without transverse carina.

Elytra at base wider than base of pronotum; side margins nearly parallel to middle, constricted back of middle, obliquely rounded to rounded, serrulate apices; disk moderately convex; sutural margin elevated posteriorly, shallow basal depressions, in addition, each elytron with an elongate depression at middle and one in apical third, depressions containing dense recumbent white pubescence; surface irregularly rugose, pubescence well spaced, short.

Abdomen beneath obsoletely reticulate, clothed with short, widely separated pubescence, suture between first two ventrals not indicated at sides; median line of pubescence short, inconspicuous; first two ventral segments unmodified. Prosternal lobe truncate with slight emargination at middle; prosternal process parallel to back of coxal cavities, then attenuate to apex. Posterior coxae with posterior margin strongly sinuate, the exterior angle not prolonged, outer portion of plate densely pubescent. Tibiae slender, anterior pair mucronate on inner side at apex. Tarsal claws similar on all feet, cleft, inner tooth broad, much shorter than outer one and not turned inward.

Length, 2.3 mm.; width, .6 mm.

Female—Differs from the male in having front of head cupreous, tibiae not mucronate, median pubescence of ventral surface not longer than others.

Described from one pair of adults collected from the foliage of palo verde (*Cercidium torreyanum* Sarg.) in Sabino Canyon, near Tucson, Arizona, August 10, 1936, by the author. Holotype male and allotype in writer's collection.

According to Fisher's key,[3] this species would run to *A. abjectus* Horn. However, it more closely resembles *A. abstersus* Horn from which it differs in male genitalia and by the presence of the elytral spots. The genitalia resemble those of *A. costipennis* Fisher, as figured by him.[3]

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[3] W. S. Fisher. U. S. Nat. Mus. Bul. 145, pp. 1–349. 1928.

Agrilus cavifrons Waterh.

Specimens which tally with the description and figure of this species were taken on the foliage of desert hackberry (*Celtis pallida* Torr.) in Sabino Canyon near Tucson, Ariz., from August 8 to 14, by the author.

Agrilus exhuachucae n. sp.

Male—Form narrow, elongate, subcylindrical, piceous; head with front bronzy green, vertex cupreous; pronotum aeneous; each elytron with a bright cupreous area covering basal fifth and extending along costal margin to apex.

Head convex, a slight trace of median depression; surface with large light punctures, pubescence sparse, obscure; antennae short, not reaching to middle of pronotum when laid along side margin, serrate from the fifth joint, outer joints wider than long.

Pronotum wider than long, widest in apical fourth, much narrower at base than apex; side margins broadly arcuate in front, oblique posteriorly, sinuate at base; when viewed from the side the marginal and submarginal carinae widely separated in front but joined on basal fifth; anterior margin sinuate, median lobe strongly rounded; basal margin emarginate at middle of each elytron; disk convex, a short median basal depression in front of scutellum, lateral depressions feeble, prehumeral carinae prominent; surface finely transversely rugose, finely punctate between rugae, each puncture bearing an inconspicuous hair. Scutellum granulate, transversely carinate.

Elytra wider than base of pronotum; side margins sinuate in front, strongly constricted at middle, broadly rounded to rounded crenulate apices; disk moderately convex, sutural margin elevated posteriorly; basal depressions deep, a faint longitudinal carina between humeri and lateral margin; surface imbricately granulose, pubescence short, well spaced, inconspicuous.

Abdomen beneath shining, reticulate, clothed with short widely separated pubescence which is longer on median line of first two segments, suture between first two ventrals well indicated at sides, first two ventrals unmodified. Prosternal lobe broadly rounded, no indication of emargination at middle; prosternal process expanded back of front coxal cavities. Posterior coxae with the posterior margin strongly sinuate, the exterior angle slightly prolonged. Tibiae slender, anterior pair mucronate on inner side at apex. Tarsal claws nearly similar on all feet, cleft, inner tooth broad, much shorter than outer one and not turned inward.

Length, 4.5 mm.; width, 1 mm.

Female—Differs from the male in having front of head aeneous, tibiae not mucronate, median line of pubescence of ventral surface not longer than others.

Described from a pair of adults collected from the foliage of oak (*Quercus* sp.) in the Huachuca Mountains, Ariz., July 21, 1936, by the writer. Holotype male and allotype in author's collection.

According to Fisher's key[3] this species would run to *A. abditus* Horn. The color markings will separate it from its allies. Superficially it resembles *A. duncani* Knull; however, the elytral apices of the two species are quite distinct.

Methia evaniformis n. sp.

(Fig. 3)

Male—Size and form of *Molorchus bimaculatus* Say; robust, piceous, area bordering eyes and antennae brunneus, elytra ochraceous.

Head convex, front perpendicular, deeply channeled between antennae; eyes deeply emarginate, but not divided, lower lobe much larger than upper one, coarsely granulate, widely separated on vertex; surface coarsely punctured, punctures contiguous, pubescence fine; antennae about twice as long as entire insect, fifth joint extending beyond tips of elytra, scape stout, second joint wider than long, third joint much longer than scape, joints four to eleven inclusive, gradually diminishing in length, scape coarsely punctured, other joints finely punctured and densely pubescent, especially on outside.

Pronotum wider than long, widest in middle, narrower at base than at apex; sides broadly rounded from apical to basal constriction; disk convex; surface confluently coarsely punctured, a transverse callous area at base, densely clothed with long silky pubescence. Scutellum triangular, channeled.

Elytra as long as wide; wider than pronotum, widest just back of base; sides broadly rounded in front, sinuate in middle, apices obliquely truncate; suture strongly sinuate; disk convex, umbone prominent, surface densely finely punctured, punctures becoming confluent apically, pubescence short, fine; under wings extending beyond tip of abdomen.

Abdomen very short, not as long as metathorax. Metasternum densely coarsely punctured. Posterior legs very long, coxae large, femora shorter than tibiae, tibiae densely clothed with long piceous hairs.

Female—Differs from the male by somewhat shorter antennae and longer abdomen.

Length, 7.5 mm.; width, 1.8 mm.

Described from specimens collected in the Davis Mountains, July 3–August 22, and Chisos Mountains, Texas, July 9, 1936, by the author.

Holotype male labeled Davis Mountains, July third; allotype and paratypes in writer's collection.

This remarkable species which was collected from the dead branches of oak (*Quercus* sp.) was very active when it landed in the umbrella and had more the appearance of one of the *Evaniidae*.

The coarsely punctured pronotum, widely separated eyes, large metathorax and long posterior legs will serve to distinguish it from the other species in the genus.

Tragidion opacum n. sp.

Male—Size and form of *T. armatum* Lec., piceous, elytra brunneous, apices piceous.

Head opaque, irregularly punctured, front concave, eyes small, finely granulate; antennae much larger than elytra, eighth joint extending beyond apices when laid over dorsal surface, scape stout, second joint slightly longer than wide, third joint longer than first two taken together, fourth shorter than third, joints five to ten gradually decreasing in length, terminal joint longest, joints four to ten slightly serrate.

Pronotum wider than long, widest in middle, narrower at apex than at base; sides oblique in front, an obtuse tubercle at middle; base constricted; disk convex, a median tubercle in front of scutellum, two on each side of anterior half and one on each side of posterior half; surface opaque, coarsely confluently punctured, each puncture bearing a recumbent piceous hair. Scutellum triangular, densely clothed with short pubescence.

Elytra at base wider than widest part of pronotum, sides nearly parallel at base, constricted at middle; parallel back of constriction, broadly rounded to emarginately truncate apices; disk convex, each elytron bearing three indistinct costae; surface densely coarsely punctured, each puncture bearing a recumbent piceous hair.

Abdomen beneath finely punctured, pubescence long. Hind tibiae bent backward at tip.

Length, 20.9 mm.; width, 5.8 mm.

Described from one male specimen in the collection of the author taken from the foliage of oak (*Quercus* sp.) in the Davis Mountains, Tex., July 4, 1936, by the writer.

This species resembles *T. armatum* Lec., but can be distinguished by the opaque, coarsely punctured pronotum, black elytral apices and color and placement of elytral pubescence.

Dorcaschema octovittata n. sp.

Male—Form and general appearance of a small specimen of *D. wildi* Uhler, background dark brown; legs and antennae lighter, body and legs clothed with recumbent white pubescence, body ornamented with fulvous stripes of the same texture pubescence.

Head with front flat, depressed between antennae, a blunt tubercle on inside of each antennal socket, a fine median line extending from pronotum to front; surface granulate in front, rugose on vertex, clothed with recumbent white pubescence marked with fulvous areas; antennae eleven jointed, fifth joint extending beyond tips of elytra, scape stout, second joint slightly longer than wide, scape and second joint asperate on upper side, third joint longer than fourth, sixth joint shorter than fifth, seventh joint longer than sixth, joints gradually increasing in length to tip, last joint longest, joints three to ten, inclusive, annulate at outer ends, white pubescence short, becoming very fine and inconspicuous on outer joints.

Pronotum longer than wide, widest back of middle; sides subparallel in front, constricted back of middle and expanded at base; anterior margin broadly emarginate; basal margin emarginate; disk convex, a vague transverse depression at base; surface transversely strigate, punctures large, irregularly placed, clothed with recumbent white pubescence, two fulvous stripes on side and a much broader one in middle, first lateral and middle stripe extending from anterior margin to basal depression, numerous long flying hairs near base. Scutellum triangular, clothed with white and fulvous pubescence.

Elytra much wider than prothorax; sides nearly parallel, broadly rounded posteriorly to rounded apices, disk convex; surface coarsely punctured, a patch of densely placed punctures back of middle on side of each elytron, clothed with recumbent white pubescence, each elytron with four fulvous stripes running the entire length.

Abdomen granulate, larger punctures well spaced, a long hair arising from each depression, clothed with white and fulvous pubescence. Legs clothed with dense white pubescence.

Length, 11.8 mm.; width, 3 mm.

Female—Differs from the male by the much shorter antennae and the smaller, less densely pubescent anterior tarsal joints.

Described from specimens taken from Mexican mulberry (*Morus celtidifolia* H. B. K.) in the Davis Mountains of Texas July 3 to 6, 1936, by the writer. The species breeds in the living trees. Holotype male, allotype and paratypes in writer's collection; paratypes in collection of the Ohio State University.

This species comes close to *D. wildi* Uhler but can be separated by the smaller size, the presence of four distinct yellow lines on each elytron and the much coarser elytral punctures. It lacks the two types of elytral punctures present in *D. wildi.*

Estola tigrina Skinn.

Reared from the dead branches of palo verde (*Cercidium torreyanum* Sarg.).

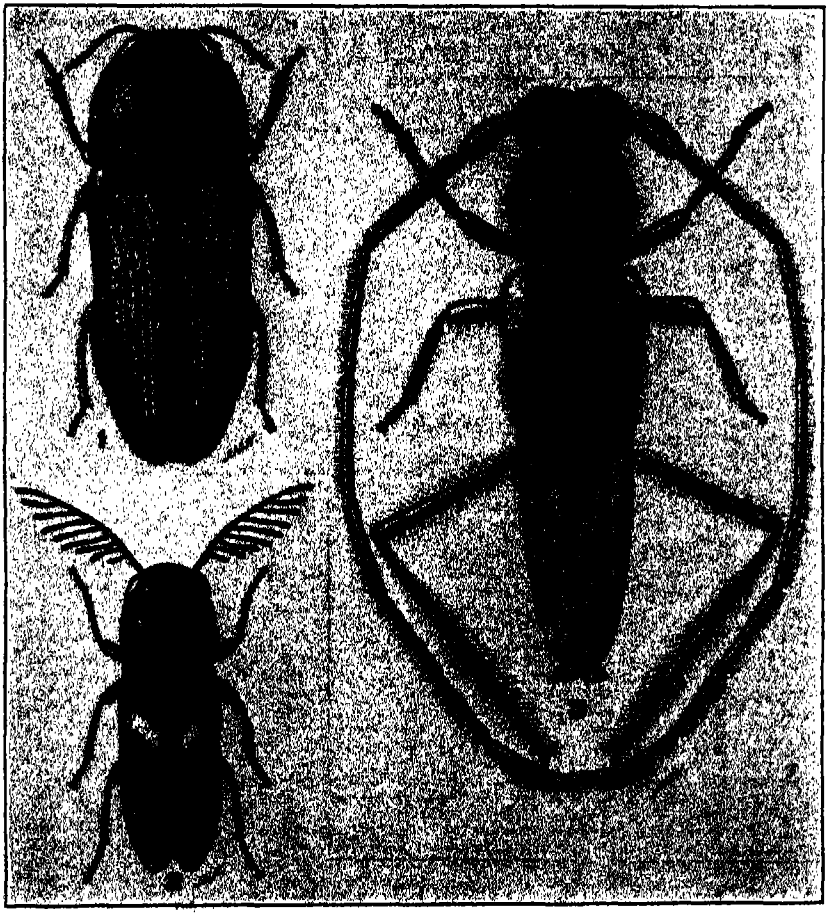

Fig. 1. *Tyndaris balli* n. sp.
Fig. 2. *Hesperorhipis mirabilis* n. sp.
Fig. 3. *Methia evaniformis* n. sp.

BOOK NOTICES

Entomological History

From his long and varied experience with entomology and entomologists Dr. Osborn has prepared and published this interesting account of the development of the science and of the persons responsible for its growth. He has dipped deep into his memories and withdrawn much of a personal nature that enlivens and enriches the book. Federal and state services, experiment stations, college departments, entomological societies and publications all form part of the historical pageant. Accounts of the outstanding insect collections are presented. The book is further personalized by the inclusion of a long series of short biographies of present-day entomologists, and an appendix of about 250 photographs.—L. H. S.

Fragments of Entomological History, by Herbert Osborn. vii+394 pp. Columbus, Ohio, published privately by the author, 1937.

The Life of Genius

Blaise Pascal receives honorable remembrance by all those who treat the history of science, for his arithmetical triangle, his principle of physics, and for many other contributions to mathematics and physics. In this new biography, however, the true proportions of his genius are disclosed in the description of his remarkable achievements in many other fields of endeavor. The exposition in both chronological and topical, this feature being permitted by a rather distinct metamorphosis in Pascal's life and in his thought. The author therefore describes, in turn, the Prodigy, the Inventor, the Convert, the Physicist, the Mathematician, the Man of the World, the Lover, the Mystic, the Penitent, the Polemist, the Philosopher, the Saint, and, in summary, the Man. Pascal, in his passionate search for the ultimate "certitude" in nature, turns radically from one intellectual sphere to the next, displaying his genius at each turn.

A large share of the book is devoted to the religious background of Pascal's period, which had great influence upon his life, even though it never completely dominated his own inductive method of logic. The book is written in a scholarly and entertaining style, and in a manner which invites much reflective thought. It is evidently the result of an exhaustive and critical study. References and controversial subjects are relegated to an appendix of notes, so as not to detract from the readability of the book.—C. W. COTTERMAN.

Pascal, The Life of Genius, by Morris Bishop. xi+398 pp. Baltimore, Williams and Wilkins Co., 1936. $3.50.

Metabolism

Doctor Holmes presents a rather frank appraisal of what we do not know about the metabolism of the individual tissues. He surveys with simplicity and brevity the general field of biochemical research, pointing out the most salient facts as well as some of the more evident blanks in our knowledge concerning the subject. The book is quite comprehensive in scope, taking up the difficult problem of organization within the cell through a consideration of the action of individual enzymes. Such topics as the metabolism of the liver, kidney and other tissues, the concept of oxidation-reduction potential, and the chemistry of the vitamins and hormones are discussed in details so fine and yet so fundamental that they make interesting and easy reading

This book should be of value to biologists, physiologists and others interested in the subject as a guide to the work that has been done and the work that needs to be done in biochemistry. Students of the life sciences should find it useful for gaining a quick acquaintance with, and a broad appreciation of the methods and present status of biochemical research. It is recommended as a supplementary text or as a reference for courses dealing with the activities of living tissues.

—HARRIET S. HYMAN.

The Metabolism of Living Tissues, by Eric Holmes. 235 pp. Cambridge, at the University Press; New York, The Macmillan Co., 1937. $2.25.

Breeding

This book is without doubt the most complete and thorough volume on animal breeding which has yet appeared. Modern genetics has contributed so much to the scientific knowledge of breeding that any adequate book on this subject must of necessity rest firmly on a genetic basis. This very fact brings the breeder up against much technical detail of genetics and biometry. Lush has done a remarkable job of combining technical and practical information into a readable and workable book. Certain unavoidable statistical concepts have been used, but so clearly are they developed, and so rationally introduced into the practical discussions that the breeder should have no difficulty in appreciating their importance. Animal husbandry departments which do not incorporate this book somewhere in their curriculum may fairly be said to be behind the times.

Following a discussion of the origin and domestication of farm animals, the general principles of genetics are briefly discussed in their relation to animal breeding. Then follow several chapters on breeding plans based on selection, on relationship, and on somatic likeness. Some general topics of interest to the breeder are taken up, followed by a chapter on sex and reproduction. The book closes with a general summary. It is not always easy to combine technical and practical information in workable form, but the result in this case is highly gratifying.—L. H. S.

Animal Breeding Plans, by Jay L. Lush. viii+350 pp. Ames, Iowa, the Collegiate Press, Inc., 1937.

Modern Alchemy

This small book contains in somewhat expanded form the subject matter of the Henry Sidgwick Memorial Lecture delivered in November, 1936. There are thirteen plates and eight figures which enhance the readability of this elementary thesis on nuclear physics. The older field of natural radioactive transformations is first reviewed. The discovery of the fundamental particles (neutron, deutron and positron) is clearly and simply presented. Special emphasis is placed upon the neutron. The methods and instruments for the production of high voltages and transmutations are briefly reviewed.

Since only the most outstanding points are touched upon, one may gain quickly from this book a very excellent perspective of the general field of nuclear physics and a glimmer of future possibilities.—M. L. Pool.

The Newer Alchemy, by Lord Rutherford. xii+67 pp. New York, the Macmillan Co., 1937. $1.50.

Educational Psychology

This book should be welcome both because the author is an authority on racial differences in mental abilities and because he has supplemented the conventional discussion of "original nature" in educational psychology texts by including a chapter on heredity. On neither count, however, is the level set by the book as a whole maintained. The materials of the chapters on motivation, learning, thinking, and achievement are well chosen and arranged. They reflect the author's fifteen years of teaching this subject matter.

With the term "selection" used to mean biased sampling, Dr. Garth's brief presentation of racial psychology concludes that, "racial differences in intelligence . . . are due to nurture and selection, and not to racial germ plasm." Since race problems are forever vexatious to students, it is regrettable that more of an answer than this is not afforded their questions. If biological differences are admitted as between individuals, it will be difficult to see why biological selection should not have been considered a possible factor as between racial groupings. With crucial data few indeed, the student could be better helped if it were pointed out that biological difference is not synonymous with biological superiority, that, taken together, marked cultural differences plus possible biological differences do not in fact produce more than small average differences between races, and that such differences as are found are slight compared to either individual differences or group differences within a race.

Galton's laws of ancestral inheritance and of filial regression might better have been omitted, especially since the student is left to suppose that the latter law alone gave rise to the doctrine of the stability of the gene. He is also left to think little more of Johannsen's work than that it "verifies our statement that if we select two parental organisms, however closely related, their progeny will still show variation." The treatments given meiosis and linkage are vague. As a fundamental concept, the particulate nature of inheritance deserves emphasis in such a chapter, and to this end the re-telling of the tales concerning the Jukes and the Kallikaks might well be spared.—B. PRICE.

Educational Psychology, by Thomas R. Garth. xvi+319 pp. New York, Prentice-Hall, Inc., 1937. $2.50.

Sound

The most recent of a series of books on Sound by Professor Miller of the Case School of Applied Science, Cleveland, deals with his own researches in this field. Curiosity about the tone qualities of flutes made of different materials was the starting point of these studies, in the year 1900. In 1908 Miller devised the phonodeik, which he developed into the most faithful device for recording the wave form of sound which was available before the advent of electronic devices of the present day. Many phonodeik records are reproduced and discussed in this book, including tones of musical instruments and typical speech sounds.

By contrast, the second half of the book deals with sound waves from rifles of various sizes up to 14 inch guns. The object at first was to investigate the concussional wave from big guns as a possible cause of shell shock. Later, the facilities of the Sandy Hook Proving Ground were used in measuring the speed of sound and its variation near the guns. Results of these studies are presented *for the first time in this book. Also included are photographs of bullets in flight* and the accompanying sound waves, made by electric-spark photography.

This book is unusual in that it is a research report intended for a wider audience than a restricted group of specialists. Dealing with the outstanding findings of a long series of studies from a comprehensive viewpoint, without the exaggerated conciseness of a journal article, it may be read with pleasure by any one interested in sound.—HAROLD P. KNAUSS.

Sound Waves, Their Shape and Speed, by Dayton Clarence Miller. xii+164 pp. New York, The Macmillan Co., 1937. $2.75.

The Living World

"The Living World" was written to serve as a text for a cultural course in biology, nature study, or elementary ecology. The book is divided into four parts dealing with (1) the biological aspects of living things, (2) the kinds of animals and where they live, (3) plant study, and (4) suggestions for field study.

The book is essentially zoological, approximately only 100 pages being devoted to plants. It contains much material of general interest about animals. Chapters on color, sound, defenses, and life spans of animals add much interest, and are valuable even though they are debatable topics. The ecology is elementary, but complicated by avoiding standardized descriptive terms, for which in several instances, words of doubtful meaning are substituted. The portion devoted to botany contains a section on insect galls and their causative organisms. The practical suggestions for study are so basic to nature study that this section could be more useful if enlarged. A reference list of books and periodical literature at the end of most chapters will facilitate independent inquiry by the better students. Because of this feature, the text may serve as a reference book for students interested in field studies, even though they have had previous courses in biology.

Although this book is a departure from books on Natural History written in a popular style, it is not sufficiently divorced from the content and technique of the commonplace elementary biology text written from a purely morphological point of view. Frequently the text fails to adhere to factual evidence and statements are made without support. A *priori* logic combined with the idea of purposive adaptation is a detriment to correct thinking by students. Several errors involving misstatement of fact were noted.—CARL VENARD.

The Living World, by Samuel H. Williams. xxii+704 pp. New York, The Macmillan Co., 1937. $3.50.

Marconi

This is an accurate, interesting and most complete account of the life of Senatore Marconi, particularly during the period of the early development of wireless telegraphy in which Marconi played so important a part. The book is completely non-technical in nature, amounting to a detailed history of the most dramatic experiments of Marconi and the development of a practical system of what he chose to call wireless telegraphy, but now known generally as radio telegraphy. Quotations from the press (the author being Radio Editor of the New York Times) form a considerable part of the text and at times are a little tiresome, but lend a definite degree of completeness and authenticity. The author, being a former ship radio operator, dramatizes the first use of wireless telegraphy in saving life on shipboard in a vivid manner. Published shortly before Marconi's death, this book gives a historical account of the development of radio communication that clearly establishes Marconi's inventive genius and shows him in the role of practical inventor, business man, and scientist.—R. C. Higgy.

Marconi: The Man and His Wireless, by Orin E. Dunlap, Jr. New York, The Macmillan Co., 1937. $3.50.

Uncertainties

Which of us has not at some time speculated about the beginning and the end of time, the boundaries of space, the possibility of an absolute post of observation and reference, simultaneity of events at different points, ultimate causality, freedom of thought and action? Here is a volume devoted to just such speculation, carefully thought out and thoroughly discussed. Not easy reading, it nevertheless holds the attention because it is so often a mirror of one's own unspoken thoughts. The warp of the discussion is the constantly changing scientific outlook, improving essentially as mathematical technics improve: the woof is man's difficulty in detaching himself from the cosmos which he is trying to describe and interpret. If one's questions are not all answered by the book, at least new lines of speculation will have been opened up.—L. H. S.

Aspects of Science, by Tobias Danzig. xi+285 pp. New York, The Macmillan Co., 1937. $3.00.

The Physiological Basis of Medical Practice

Physiology has long been known as the hand-maiden of medicine. The physiologist who has the responsibility of instructing medical students may rightly be expected to point out to his students the clinical applications of his science and to emphasize especially those aspects of the subject which are of value in the diagnosis and treatment of pathological conditions. Professors Best and Taylor, the eminent physiologists of the University of Toronto, have kept these facts constantly in mind in the preparation of their new book which has met with instantaneous and signal success. In spite of the fact that a generous proportion of the book is devoted to a consideration of the practical aspects and clinical applications of the subject, fundamental and classical physiology has by no means been neglected. Indeed the outstanding virtue of the book is its comprehensiveness. In it one can find the most recent developments in the pure science of physiology as well as a wealth of material which relates these developments to the practice of medicine. The book is written in a lucid and interesting style and its contents presented in logical sequence. It is divided into eight sections as follows: (1) the blood and lymph, (2) the circulation, (3) respiration, (4) the excretion of urine, (5) digestion, (6) metabolism and nutrition, (7) the ductless glands, and (8) the nervous system. A dogmatic attitude on controversial subjects has been studiously avoided. In such cases the important evidence on both sides is presented from an unbiased point of view. The book is much more than a test-book of medical physiology, it is an outstanding reference work for medical practitioners and for biologists in general.—F. A. Hitchcock.

The Physiological Basis of Medical Practice, by Charles Herbert Best and Norman Burke Taylor. xxiii+1684 pp. Baltimore, William Wood and Company, 1937. $10.00.

THE OHIO JOURNAL OF SCIENCE

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FOREWORD

In 1933 the Ohio State Chapter of the Society of the Sigma Xi committed itself to the policy of sponsoring at biennial intervals series of lectures treating various aspects of some central scientific topic. At the completion of such a series of lectures it was the plan of the executive committee that it should be published and distributed at cost. Two such symposia have already been issued by the Chapter. In 1933 a Symposium on Metabolism was published and in 1935 the Chapter issued a Symposium on the Nucleus of the Atom. The success of these first two publications has been very gratifying and it is with a feeling of confidence as well as of pride that the Chapter presents the published version of this third series of lectures, A Symposium on Hormones.

The authors of the various papers included in this series are authorities in their several fields, and their researches constitute major contributions to our knowledge of the hormones. Naturally the treatment has not been exhaustive. The field is so broad and the physiology involved so complex that of necessity the several authors have selected some more or less limited aspect of the subject for elucidation. Furthermore limited time and facilities have made necessary the omission of certain of the hormones and therefore this volume contains no discussion of the hormones of the parathyroids, the thymus, or the pineal gland.

As was the case in the two preceding symposia, publication is made possible through the co-operation of the Ohio Journal of Science, and the executive committee of the Ohio State Chapter of the Society of the Sigma Xi wishes to express its appreciation to the editor and business manager of this Journal and to all others concerned for the splendid co-operation which made the series of lectures so successful and which now makes their publication possible.

F. A. HITCHCOCK, *Secretary*.

Physiology Laboratories,
The Ohio State University.

EDITOR'S NOTE

The JOURNAL is again pleased to publish a Sigma Xi Symposium on a topic of current interest. The prompt publication of these lectures in symposium form is made possible by the financial assistance and the editorial co-operation of the Society of the Sigma Xi.—L. H. S.

THE GROWTH HORMONES FOUND IN PLANTS

GEORGE S. AVERY, JR.
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INTRODUCTION

Just what is a hormone? This question is the one which first comes to mind if one is not familiar with the subject. The term "*hormone*" is derived from a Greek work meaning "to arouse to activity." It was first suggested by Hardy and used by Starling in 1906 in reference to the substance *secretin*. In 1914 Starling defined a hormone as "any substance normally produced in the cells of some part of the body and carried to distant parts which it affects for the good of the body as a whole." This definition as applied to animal physiology is equally useful to the plant physiologist. Indeed, the naturally occurring plant hormones, as we now understand them in higher plants, are formed or stored in certain regions of the plant and moved to others where they become effective. The common characteristic of these compounds that lets us place them in the category of hormones is the fact that when present in very minute quantities, they bring about *growth* if other conditions such as food and water supply are not limiting. Their influence on growth is out of all proportion to the low concentration in which they occur.

The discoveries during the past 25 years of certain facts concerning the activity of plant growth hormones have given a clue to the long puzzling problem of plant responses to light and gravity, and through studies on these tropisms we have gained much new information regarding normal growth.

In short, the growth hormone theory is this: Assuming an adequate supply of food and water, growth will go on only if growth hormone, or *auxin* (as it is known also) is present. Without auxin, no growth takes place. The presence of auxin in minute quantities promotes cell stretching (elongation) in the direction of the long axis of an organ such as a petiole, or stem, hence auxin may be considered as promoting *polarized* growth—greater growth in length than in any other direction. For the present, at least, this statement must be limited to aerial portions, or shoots, of plants.

The relationship of cell division to the naturally occurring auxins is not sufficiently clear as yet to be discussed here, and so we shall assume for the present, at least, that these substances exercise their effect mainly on cell elongation.

All the earlier studies on auxin were made in connection with grass seedlings, mostly oats, *Avena sativa*. Other more recent work has been done on dicotyledonous seedlings such as lupine, broad bean, sunflower, etc. For the sake of clarifying the discussion that follows, diagrams of the oats and sunflower seedlings are given in Fig. 1. Growth hormones have been investigated also in the leaves, stems, flowers and roots of various kinds of plants at different stages in their development.

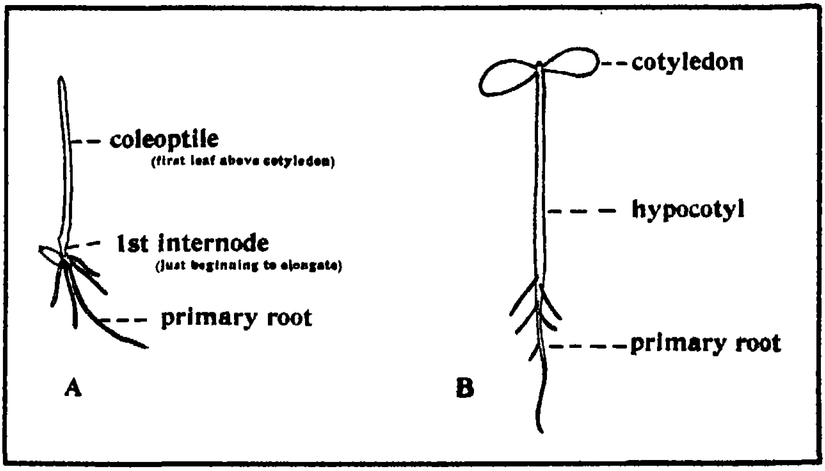

Fig. 1. A, seedling of *Avena sativa*. The coleoptile (cylindrical sheathing leaf and first above the cotyledon) has been used widely in studies on plant growth hormones. The single cotyledon remains enclosed in the old seed coat. B, seedling of typical dicotyledonous plant.

The comments that follow will touch upon such topics as the discovery of plant hormones, how their concentration may be measured, and more briefly on their chemistry, occurrence, effectiveness, formation, nomenclature, translocation, relation to normal growth, tropisms, and other life phenomena. This is essentially the outline followed by Professor Boysen Jensen in his book "Die Wuchsstofftheorie."

THE DISCOVERY OF HORMONES IN PLANTS

The history of hormone investigations extends over the past twenty-five years, and Boysen Jensen should doubtless receive credit for the discoveries which later led to the unquestioned demonstration of the presence of growth hormones in plants. His studies, published in 1910–11, indicated the presence of some sort of a chemical substance which streamed from the tip of the *Avena* coleoptile downward toward its base. If the light came from one side (hereafter referred to as *unilateral* light), the substance apparently streamed downward on the darkened side, and the coleoptile elongated on the dark side. The result was that the tip bent toward light. This was demonstrated by inserting a mica plate in a transverse direction into the back and front sides of coleoptiles, just below their tip (Fig. 2, A and B). When inserted into the back side this usual phototropic response to unilateral light did not occur. He then removed the tip of the coleoptile and placed a thin sheet of gelatin on top of the coleoptile stump. Following this, the tip was replaced in its original position—except that a layer of gelatin lay between it and the stump. When the coleoptile was exposed again to unilateral light, the usual phototropic bending took place. This led to the important conclusion that the movement of a chemical substance must be involved in this growth response.

A series of experiments by other workers followed. Paal (1918), removed the tip of the coleoptile and set it back on one side of its stump (Fig. 2 C). The result was a curvature away from the replaced tip (positive curvature), which indicated that a growth substance of some sort was moving downward from the replaced tip. Stark (1921) extracted juice from coleoptiles and made it up in agar blocks. When such an agar block was placed on one side of the coleoptile stump (see Seubert, Figure 2 D), curvature took place toward the block; this *positive* curvature indicated the presence of some sort of a growth inhibiting substance. Seubert (1925) was the first to demonstrate that growth hormone could be extracted from plant and animal material; agar blocks were prepared with saliva, diastase and malt extract, and when these were applied to coleoptile stumps (Stark's method), positive growth curvatures occurred (Fig. 2 D).

This line of investigation was followed up by Went (1928). He showed that the decapitated coleoptile tips such as Paal had replaced on one side of the stump, could be placed on a small agar surface, and that growth hormone would diffuse out of the

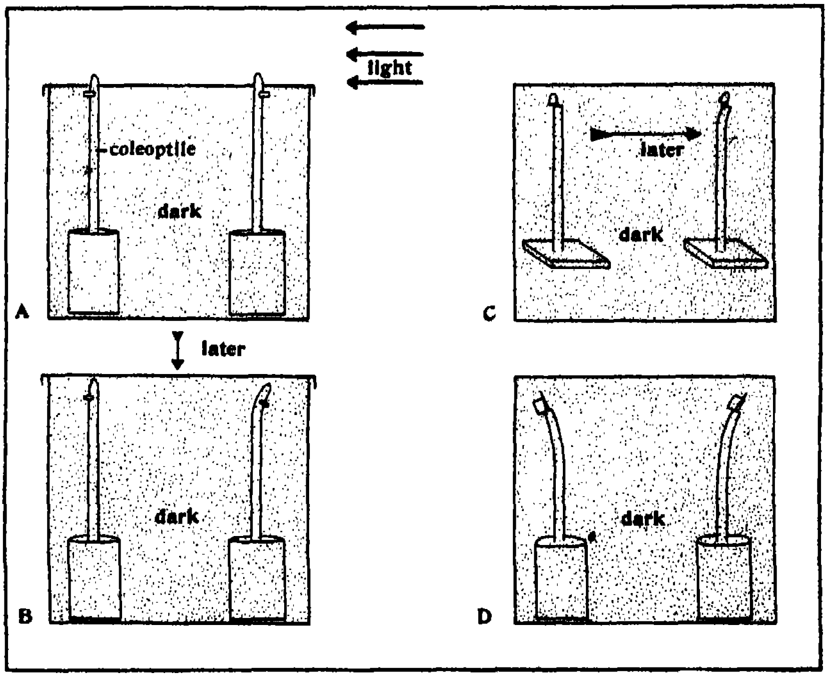

Fig. 2. A and B, diagrammatic representation of the experiments of Boysen Jensen (1910–11). A, *Avena* seedlings growing in soil in small glass containers, in total darkness except for the coleoptile tips which extend into the light (light coming from the right hand side, *unilateral* light). Before receiving the unilateral light, small sheets of mica were inserted on the front and back sides, immediately below the tips of the coleoptiles. After a short exposure to light, the coleoptiles were in total darkness. B, later, the coleoptiles with the mica insert on the side which was illuminated bent in the direction of the illumination while those with the mica insert on the back side did not bend. This indicated that a growth stimulus of some sort ordinarily passed down the coleoptile on the side away from the light, causing it to bend toward the light. (*When the coleoptile tip was severed from the stump, then replaced in its normal position but with a layer of gelatin between it and the stump, the response to unilateral light took place as usual*—not illustrated.) Boysen Jensen interpreted these experiments as indicating that the stimulus was chemical in nature, thus laying the ground work of the hormone theory. C, Paal (1918) worked with empty coleoptiles of *Coix*. After severing from the seedlings, the coleoptiles were supported in moist sand. He showed that the coleoptile tip could be removed and replaced on one side with a resulting curvature away from the tip. This indicated that growth stimulating substance was being dispersed from the coleoptile tip. D, by decapitating coleoptiles and using agar blocks according to the method of Stark (1921), Seubert (1925) was the first to show that growth hormone could be extracted from plant and animal material. When the agar was infiltrated with saliva, diastase, or malt extract, and small blocks of such agar were placed unilaterally on *Avena* coleoptile stumps, growth curvatures occurred (right). Curvatures toward the block were induced (left) when growth inhibiting substances were present in the agar.

tips into the agar (see diffusion from leaf in Fig. 3). He cut the agar into small blocks, and if such blocks were placed unilaterally on coleoptile stumps, positive curvatures were obtained, like those of Seubert a few years before. Then Went discovered that this curvature was proportional, within limits (angles of 15° to 20°) to the amount (later shown to be concentration) of growth hormone present in the agar. This marked the discovery of a *quantitative* method for working with plant hormones; the method (Fig. 3) makes it possible to determine hormone *concentration*, and its importance cannot be overestimated. The field has been an increasingly active one ever since Went's discovery.

METHOD FOR DETERMINING THE CONCENTRATION OF AUXIN IN AN UNKNOWN

No chemical test has been devised which provides a ready and simple means of qualitative or quantitative detection of the minute amounts of auxin present in living plants. This means that some other means must be used for detection. Just as the animal physiologists resort to rabbits, guinea pigs and rats for tests with animal hormones, the botanist also resorts to a biological measuring stick. The botanical "guinea pig" or test object for plant hormones, is the *Avena* coleoptile, and Went's technique, as modified by others and himself, is illustrated in Figure 3.

The laboratory in which the tests are carried on should be maintained at 79° F. and approximately 90% humidity, and pure fresh air should be supplied at regular intervals. It should be lighted only with red or orange light, of wavelengths which bring about no phototropic response in the test plants.

If for any reason it is not possible to apply the agar blocks approximately 40 minutes after decapitation, the coleoptiles may be decapitated a second time by removing a short segment at the top of the stump. After such "double" decapitation, maximum sensitivity is reached after about 3 hours.

A little more than 2 hours before a test is made, it is necessary to prepare the material in which the hormone concentration is to be determined. Let us assume that it is a vigorously growing leaf, or stem tip of the tobacco plant that is to be tested. Not knowing just what to expect at first, it would be well to use the tips of 2 or 3 plants. These are cut from the plants and placed on rectangular pieces of agar, prepared as indicated in Figure 3

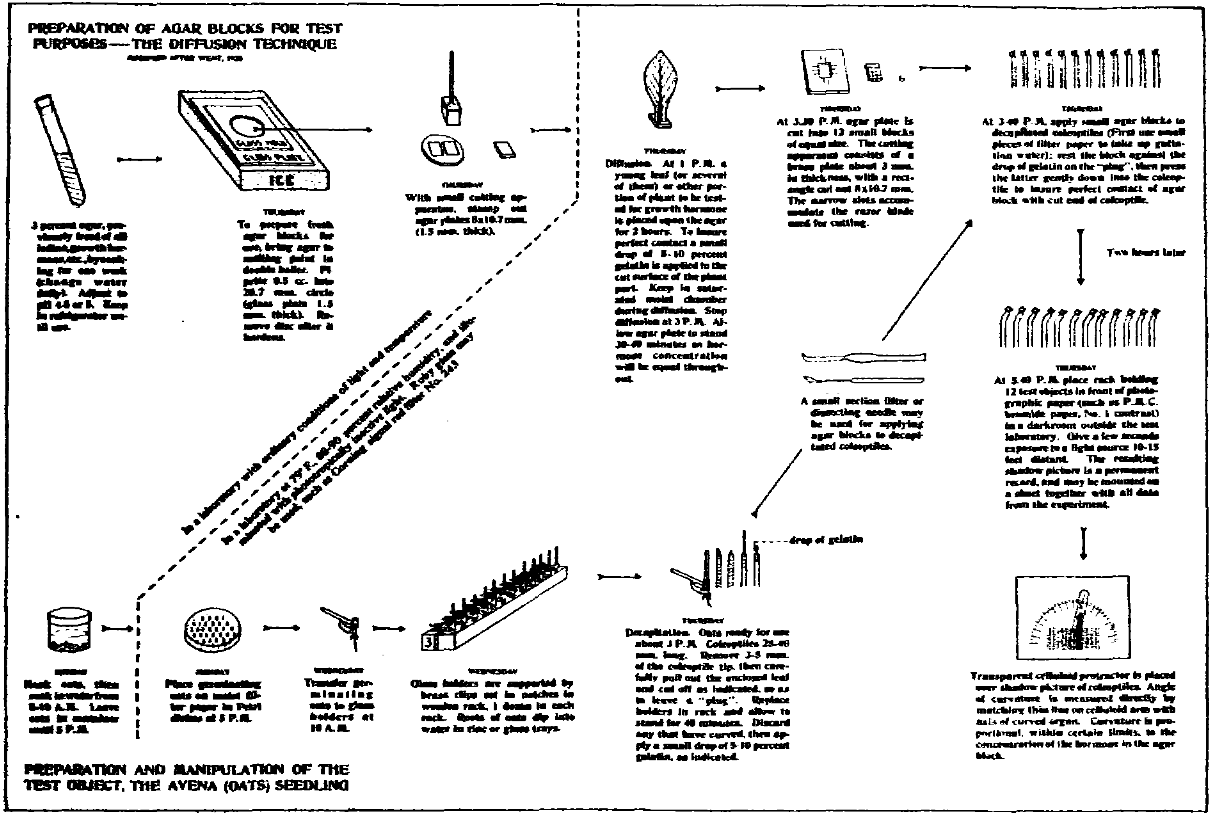
PREPARATION OF AGAR BLOCKS FOR TEST PURPOSES—THE DIFFUSION TECHNIQUE
ADAPTED AFTER WENT, 1928
3 percent agar, previously freed of all indinol, growth hormone, etc., by soaking for one week (change water daily). Adjust to pH 4.8 or 5. Keep in refrigerator until use.
ICE
TUESDAY
To prepare fresh agar blocks for use, bring agar to melting point in double boiler. Pipette 0.5 cc. into 20.7 mm. circle (glass plate 1.5 mm. thick). Remove disc after it hardens.
THURSDAY
With small cutting apparatus, stamp out agar plates 8x10.7 mm. (1.5 mm. thick).
THURSDAY
Diffusion. At 1 P.M. a young leaf (or several of them) or other portion of plant to be tested for growth hormone is placed upon the agar for 2 hours. To insure perfect contact a small drop of 5-10 percent gelatin is applied to the cut surface of the plant part. Keep in saturated moist chamber during diffusion. Stop diffusion at 3 P.M. Allow agar plate to stand 30-40 minutes so hormone concentration will be equal throughout.
THURSDAY
At 3.30 P.M. agar plate is cut into 12 small blocks of equal size. The cutting apparatus consists of a brass plate about 3 mm. in thickness, with a rectangle cut out 8x10.7 mm. The narrow slots accommodate the razor blade used for cutting.
THURSDAY
At 3.40 P.M. apply small agar blocks to decapitated coleoptiles (First use small pieces of filter paper to take up guttation water); rest the block against the drop of gelatin on the "plug", then press the latter gently down into the coleoptile to insure perfect contact of agar block with cut end of coleoptile.
Two hours later
THURSDAY
At 5.40 P.M. place rack holding 12 test objects in front of photographic paper (such as P.M.C. bromide paper, No. 1 contrast) in a darkroom outside the test laboratory. Give a few seconds exposure to a light source 10-15 feet distant. The resulting shadow picture is a permanent record, and may be mounted on a sheet together with all data from the experiment.
A small section lifter or dissecting needle may be used for applying agar blocks to decapitated coleoptiles.
drop of gelatin
Transparent celluloid protractor is placed over shadow picture of coleoptiles. Angle of curvature is measured directly by matching thin line on celluloid arm with axis of curved organ. Curvature is proportional, within certain limits, to the concentration of the hormone in the agar block.
In a laboratory with ordinary conditions of light and temperature
In a laboratory at 75° F., 85-90 percent relative humidity, and illuminated with phototropically inactive light. Ruby glass may be used, such as Corning signal red filter No. 243
MONDAY
Husk oats, then soak in water from 8-10 A.M. Leave oats in container until 5 P.M.
MONDAY
Place germinating oats on moist filter paper in Petri dishes at 5 P.M.
WEDNESDAY
Transfer germinating oats to glass holders at 10 A.M.
WEDNESDAY
Glass holders are supported by brass clips set in notches in wooden rack, 1 dozen in each rack. Roots of oats dip into water in zinc or glass trays.
3
THURSDAY
Decapitation. Oats ready for use about 1 P.M. Coleoptiles 25-40 mm. long. Remove 3-5 mm. of the coleoptile tip, then carefully pull out the enclosed leaf and cut off as indicated, so as to leave a "plug". Replace holders in rack and allow to stand for 40 minutes. Discard any that have curved, then apply a small drop of 5-10 percent gelatin, as indicated.
PREPARATION AND MANIPULATION OF THE TEST OBJECT, THE AVENA (OATS) SEEDLING

Fig. 3. Went's (1928) quantitative method of demonstrating the hormone content of plant parts. The time schedule is indicated by days for convenience sake only. The curvature of the *Avena* coleoptile is proportional, within certain limits, to the concentration of the growth hormone.

In our laboratory we use the size agar plate suggested by Dolk and Thimann: 8 x 10.7 x 1.5 mm. It dries out less rapidly than the smaller blocks. A small amount of 5 or 10% gelatin is applied to the cut end of the young tobacco stems and they are placed upright on the agar, then allowed to stand in a moist chamber for 2 hours. After removing the tobacco tips at the end of the 2 hour period, the agar is cut into 12 small pieces of equal size. In the meantime the coleoptiles have been decapitated, and we are ready to proceed. Each of the blocks is placed as indicated (Fig. 3) on a decapitated coleoptile. After the agar blocks have been in place 2 hours, the rack of 12 test plants may be photographed (shadow picture on bromide paper is simplest). The angles of curvature can then be determined with a protractor, and the results may be expressed in degrees of coleoptile curvature, or in the various units suggested by different authors. Curvatures up to about 20° are directly proportional to the concentration of the hormone present in the agar block.

If a liquid of unknown hormone content is to be tested, the agar should be made up with various dilutions of the unknown. Each of these dilutions should be tested, so that certain of them, at least, will fall within the range of quantitative results.

A typical schedule for diffusion of plant material and the subsequent tests is as follows:

Material	Start Diffusion	Stop Diffusion	Decapitate	Apply Agar Blocks	Photograph
A	9:00 a. m.	11:00 a. m.	10:50	11:32	1:32 p. m.
B	9:15	11:15	11:05	11:47	1:47
C	9:30	11:30	11:20	12:02	2:02
D	9:45	11:45	11:35	12:17	2:17
E	10:00	12:00	11:50	12:32	2:32
F	10:15	12:15	12:05	12:47	2:47
G	10:30	12:30	12:20	1:02	3:02
H	10:45	12:45	12:35	1:17	3:17
I	11:00	1:00	12:50	1:32	3:32
J	11:15	1:15	1:05	1:47	3:47
K	11:30	1:30	1:20	2:02	4:02
L	11:45	1:45	1:35	2:17	4:17
M	12:00	2:00	1:50	2:32	4:32
N	12:15	2:15	2:05	2:47	4:47
O	12:30	2:30	2:20	3:02	5:02
P	12:45	2:45	2:35	3:17	5:17

For one operator to run 16 dozen test plants in a little more than 8 hours, as outlined above, requires experience. It is possible to run half as many with greater ease. With half the number, diffusion can be started at 5 minute intervals, then the operations will not overlap. With a little practice it is possible to decapitate a rack of one dozen coleoptiles in 2 or 3 minutes. Agar blocks can be applied in a similar length of time. In order not to get behind schedule if anything unforeseen happens, it is well to allow at least 5 minute periods between diffusions.

There are other ways than the *Avena* method of detecting the presence of the auxin, but they have not been as satisfactory in terms of quantitative results. Of course the *Avena* technique does not work for all kinds of plant material, but in most instances it has proved itself useful. Skoog (in press) has shown that by removing the cotyledon and endosperm from the *Avena* seedling ("de-seeding"), its sensitivity as a test object can be increased. *Cephalaria* is a sensitive test object, but it does not give curvatures proportional to concentration over a very wide range.

CHEMISTRY AND OCCURRENCE

To date three hormones have been demonstrated as occurring naturally in plants. In certain fungi it has been possible to demonstrate the presence of a growth hormone which Kögl, Haagen Smit & Erxleben have referred to as *heteroauxin*. From various higher plants and other sources these same investigators have isolated two other hormones, designated by them as auxin *a* and auxin *b*. The information they have given us constitutes the greater part of our present knowledge of the chemistry of auxins. The empirical formula of heteroauxin is $C_{10}H_9O_2N$; of auxin *a*, $C_{18}H_{34}O_5$; and of auxin *b*, $C_{18}H_{30}O_4$. Auxin *a* is a monocyclic tri-hydroxy-keto carboxylic acid with one double bond, and heteroauxin is 3-indole acetic acid, a compound known for 50 years before its potency as a plant hormone was discovered.

Pure crystals of auxin *a* are reported to have a melting point of 196° C; auxin *b* of 183°C and heteroauxin of 165°C. Auxin *a* is stable in the presence of acid and is sensitive to alkali. Heteroauxin is just the opposite, while auxin *b* is destroyed by both acids and alkalies. Auxins *a* and *b* lose their activity after a few months. They have not yet been synthesized.

Although the above compounds have diverse chemical characteristics, they apparently all promote cell elongation (in their naturally occurring state) in the direction of the long axis of stems or other parts of the shoots of plants.

The chief experimental source of auxins has been from human urine, about 80% of the growth hormone concentration of which is auxin *a* and 20% heteroauxin. The content in urine is appreciable following the ingestion of butter, salad oil and other fats at meals. Normal and pathological animal tissues have been shown to have auxin present in them. Auxins have been shown to occur also in numerous plant products, such as corn oil and malt, and in the vegetative and reproductive parts of many kinds of mono- and dicotyledonous plants. Pollens of many kinds of plants are an especially rich source, as are the embryo and endosperm of many seeds. Fungi such as *Rhizopus* and *Aspergillus* produce heteroauxin, and the alga *Valonia* has been found to contain auxin. There is every reason to suppose that these or similar growth hormones occur universally in plants.

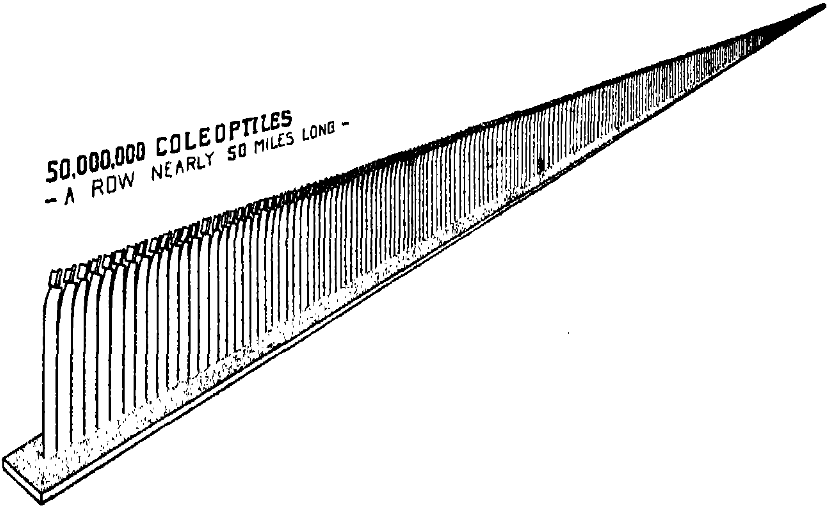
50,000,000 COLEOPTILES
- A ROW NEARLY 50 MILES LONG -

Fig. 4. One milligram of pure auxin *a* is sufficient to bend 50,000,000 coleoptiles to an angle of 10°, if applied unilaterally in agar blocks. 50,000,000 coleoptiles, if placed side by side, would make a row nearly 50 miles long. At this rate, four pounds of auxin *a* would bring about a 10° curvature in a row of coleoptiles extending from earth to sun!

EFFECTIVENESS

Auxins *a* and *b* are about equally effective in promoting growth. It has been estimated that one milligram of either compound is capable of bringing about a curvature of 10° in fifty million decapitated coleoptiles, if applied unilaterally in agar blocks, as previously indicated. Convert this into some figure that is more nearly comprehensible. There are a few over one million coleoptiles to the mile if they stand closely side by side, so one milligram of either compound is capable of bringing about a 10° curvature in nearly 50 miles of coleoptiles (Fig. 4). Heteroauxin is approximately one-half as effective, i. e., one milligram of it would bend only 25 miles of coleoptiles!

Substances of synthetic origin (other than 3-indole acetic acid) have been tested on the *Avena* coleoptile, but none tested so far has been quite as effective as the naturally occurring auxins. For example, one milligram of one of the indole propionic acids would bend 5 miles of coleoptiles, and the same amount of a methyl-indole acetic acid would bend only 1½ miles of coleoptiles, etc. These synthetic substances have been designated as "growth substances," and indeed many of them do appear to behave as such. It may be that the concentrations in which it is necessary to use them to get a given effect will be so high that they cannot be considered hormones. They do not need to concern us for the present for they have not been shown to occur naturally in plants. But that they are of the utmost practical importance, whether hormone-like or not, cannot be denied, and their applications in horticulture with regard to rooting and other phenomena will be discussed by Dr. Zimmerman in a later lecture in this series.

NOMENCLATURE

Any chemist would tell us that even with our present knowledge of the chemistry of plant growth hormones, we ought to call them by their chemical names. For example auxin *a* is auxentriolic acid, auxin *b* is auxenolonic acid, and heteroauxin has already been referred to as 3-indole acetic acid. But there are many brands of chemical nomenclature. 3-indole acetic acid is also known as β-indolyl acetic, β-indole acetic and indole-3-acetic acid. We might well adopt the names botanists have provided, such as growth substance[1], growth regulator[2], growth hormone and phytohormone; they refer more particularly to the physiological response. The animal hormonists have outdone the botanists, and a score or more of physiological names have been applied to sex hormones alone. The nomenclature will become more settled as our knowledge of the field advances.

[1-2] The terms "growth substance" and "growth regulator" probably ought to be dropped gradually from the literature, because the nutritional substances even when present in very small amounts (minerals, gases, and organic foodstuffs) are also growth substances and growth regulators.

FORMATION, STORAGE, AND PHYSIOLOGICAL REGENERATION

We are almost entirely in ignorance regarding the synthesis of auxin by the living plant. The production of heteroauxin by molds and bacteria has been studied in relation to the character of the nutrient substratum; it has been found that glucose, peptone, glucose ammonium tartrate, tryptophane and other compounds favor its formation. Within limits, higher temperatures have been found to result in increased production of growth hormone. It has been found too, that its formation in young leaves and other growing parts of green plants will not take place in the absence of light. Seedlings are enabled to grow for many days in darkness because they have a stored supply of auxin present in the seed; when this is exhausted they cannot grow further, even though they possess adequate food and water. Just how this auxin is stored in seeds we do not know. Presumably it is in an inactive form, and does not become active until the seed absorbs water. Some seeds require a short exposure to light before they will germinate. This doubtless indicates that light in some instances activates in some way the inactive stored form of auxin.

There are many references in the literature which indicate that growth hormone is formed at the tip of the *Avena* coleoptile, from which point it moves downward, bringing about growth. From what we know now, this interpretation seems untenable. It is more likely that the auxin, probably in its inactive form, is moved from the endosperm and cotyledon upward through the vascular bundles to the tip of the coleoptile, where it becomes activated before being dispersed downward.

There are many studies pertaining to "physiological regeneration," a phenomenon peculiar to the coleoptile of grasses, and which may be explained as follows: When the coleoptile tip is removed, the immediate source of the growth hormone supply is removed also and the growth of such a decapitated coleoptile, as would be expected, gradually comes to a stop, i. e., the hormone present in the tissues of the coleoptile stump is used up. At this time the coleoptile is not responsive to unilateral light or to gravity. But after a few hours a new "physiological tip" becomes established at the upper end of the stump; as the auxin moves downward through the tissues from this new center of dispersal, growth starts again, and the organ again is sensitive to unilateral light and to gravity. This physiological regeneration, as it is called, is probably not "regeneration" in the sense originally intended. As we now understand it, the endosperm and embryo are places of storage of growth hormone, and its probable movement upward in the vascular bundles has been indicated above. If the endosperm is removed, physiological regeneration does not occur after about ten hours have elapsed. From this it might reasonably be expected that it would move upward (in its inactive form) in a decapitated coleoptile as well as in an intact one, and that it would similarly be dispersed downward (in its active form) after the wound shock has subsided. There is considerable evidence to support this interpretation but the secret of "activation" at the tip, if this is what happens, still remains to be discovered.

MOVEMENT OF THE GROWTH HORMONE IN PLANTS

This is a subject of utmost interest. The naturally occurring growth hormones apparently move only in a morphologically basipetal direction, as for example, from the tip downward in the *Avena* coleoptile, or from the embryological regions of young stem tips downward in stems, or downward from the storage place in the cotyledons into the hypocotyls of dicotyledonous seedlings. This one-way movement has been designated as "polar" transport. It apparently holds true in young or moderately mature tissues, but in old tissues the growth hormone has been demonstrated to move in either direction. Of course it does not ordinarily occur in mature tissues. Anesthetization disturbs the "polarity" of transport.

It has been discovered recently that certain of the synthetic growth hormones can be applied to the plant and be transported upward. This apparently is due to their getting into the transpiration stream, in which they are carried upward through dead xylem ducts. This is not out of harmony with the facts given above in regard to polar movement through living tissues.

The velocity of movement is about 1 centimeter per hour, a rate considerably greater than could be accounted for by diffusion; the *rate* apparently is not affected by ordinary ranges of temperature and is independent of any concentration gradient existing in the plant. Anesthetization reduces this rate to that of simple diffusion.

Several explanations have been offered to explain the mechanism of movement: diffusion, protoplasmic streaming, electrophoresis, etc. The latter has found considerable support in studies of the past year or two. The acid character of the growth hormones suggests that they might be moved toward the positively charged pole in an electrical circuit, an explanation which has been reported as verified experimentally *in vivo* and *in vitro*, under an applied electric potential. This does not mean that protoplasmic streaming and other factors are not involved. Our information on this, as on other things, is as yet incomplete.

GROWTH HORMONES AND NORMAL GROWTH

From what has been said it is clear that we are dealing with minute amounts of certain chemical substances which are synthesized by plants. These substances move and "behave" characteristically, and most important of all, *growth* depends upon their presence. Cells apparently cannot elongate without them.

If auxin applied in agar blocks to decapitated *Avena* coleoptiles gives curvatures proportional to concentration, there ought to follow a direct correlation between growth intensity and hormone concentration in normally growing plant organs (within limits, of course). This has been demonstrated in a few plants—in the *Avena* coleoptile, lupine hypocotyl, and the foliage leaf of tobacco. The implication is an important one: growth vigor, other things being equal, must be associated with the synthesis, accumulation, effective use, or destruction of auxin. Van Overbeek (1935) reports that a dwarf strain of maize derives its dwarf character from the fact that enzyme systems are present which destroy the hormone more rapidly than in normal plants.

The facts regarding the normal growth of *roots* seem, at first glance, to be in opposition to the thesis of the growth substance theory. Root growth is inhibited by concentrations of the hormone which ordinarily promote growth in stems, coleoptiles, petioles of leaves, etc. While this may give us a clue to the inherent difference in roots and shoots, it is without an entirely satisfactory explanation in terms of growth hormone. But certain investigators regard it as the normal and expected behavior. The argument is this: When a root is decapitated, the growth of its stump is accelerated for a short time, and if the root tip is placed unilaterally on the stump, growth is *inhibited* on that side (curvature *toward* the root tip); the response is the same if a coleoptile tip is placed unilaterally on the root stump, although we know that a root tip or coleoptile tip placed unilaterally upon a decapitated coleoptile gives a growth promoting effect (curvature *away* from the applied object). If a root is immersed in an auxin solution, its growth in length may cease entirely. This can mean but one thing: the normal response of roots to auxin applied in the manner indicated is to slow down their growth rate, i. e., growth inhibition. As regards roots, then, the auxins are not growth promoting hormones; they are growth inhibiting! Concentration of hormone may turn out to be the answer to this puzzling difference between roots and shoots.

A discussion of normal growth ought to include some mention of how hormones actually work, i. e., their mechanism of action. There is evidence that they are used up in the process, not as building stones, but as activators influencing in some way the plasticity of cell walls. The walls become stretched in growth and do not shrink back to their previous smaller size. There must be either a rearrangement of the structural units of the cell wall, or an active deposition of new wall building material. The first urge for a cell to grow may come from wall extension, the wall taking the lead and thus making possible the entrance of more water. Although in its movement the auxin passes through the end walls of cells, only the side walls are affected—they are the ones which increase their length. There is a real challenge here. We do not know the fundamentals.

TROPISMS

It was brought out in the brief history of the subject that Boysen Jensen's discovery came about through experiments on the response of the coleoptile to unilateral light. This phenomenon of phototropic response is well known, and we expect it whenever a potted plant is placed near a window in our house. Its younger stems always bend toward the light. Any such response must be due to unequal growth on the opposite sides of a light-stimulated organ. The darkened side grows more rapidly than the lighted side. It has been shown that when a young stem is given light from one side only, the growth hormone becomes unequally distributed. More of it is transported to the darkened side, hence a greater concentration of it on the darkened side. Greater concentration of the hormone on the darkened side of the stem gives what might be expected, i. e., greater growth on that side. The result: bending toward the light. Exactly how light brings about this differential distribution of the hormone, we do not know, but from the suggestions already made in connection with movement of auxin in the plant, we would be led to suspect that it is at least partly due to a light-induced change in the electric potential across the organ.

The usual responses of stems of plants to gravity are well known also; if a potted plant is oriented on its side we know that in a short time the young main stem and leaves will turn upward—the so-called "negatively geotropic" response. The work of Dolk and others has shown that this is due to the greater accumulation of the hormone on the under side of an organ such as a coleoptile or stem, hence *more rapid cell elongation on the under side*, and the resulting upward curvature.

Roots behave differently. That the main roots of most plants grow directly toward gravity is common knowledge. If they are placed in a horizontal position, the young growing tip turns downward, i. e., *the cells on the upper side* elongate more rapidly, and cause the growing tip to bend downward. It has been shown that this is due to the accumulation of the hormone on the lower side of the root, where its presence inhibits cell elongation; hence the root tip turns downward in its growth.

Here, then, is the connecting link between the environment and the growing plant. The tropic responses of plants to two of the most important stimuli in their environment, light and gravity, are brought about by the same agent, the growth hormone which occurs naturally in their tissues. This has come to be known as the growth hormone explanation of tropisms. Although some of the details of our explanation may be incorrect, the evidence is overwhelming, and strikingly simple.

Tropic responses can be induced in young portions of plants by applying growth hormone to the outside of the plant in some suitable solvent such as lanolin, but this is to be discussed by others.

THE RELATION OF HORMONES TO OTHER LIFE PROCESSES

Most of what has been said up to this point finds its explanation in the fact that plant growth hormones regulate cell elongation. Other work reported in the past year or two suggests that numerous other effects may be due in whole or in part to the activity of these same hormones: (1) It has been reported that they stimulate the production of new roots. (2) The so-called apical dominance of the terminal bud over the lateral buds has been attributed to the inhibition of the lower axillary buds by growth hormone moving downward from the terminal bud past them. (3) Cell division in the cambium and in callus tissue has been attributed to auxin also. These observations are of great interest and are very suggestive. Whether the effects mentioned will utimately be attributed to hormones remains for future investigations to determine.

SUMMARY AND CONCLUSIONS

Plant hormones (auxins), like animal hormones, are produced in very small quantities in one part of the organism (young, vigorously growing parts) and moved to another part where they become active. Their main role, as we now understand it, is the regulation of cell elongation; other roles have been attributed to them.

The tropic response of plants to two of the most important stimuli in their environment, light and gravity, are brought about by the movement of auxin from one part of a stimulated plant organ to another. This has come to be known as the growth hormone explanation of tropisms.

Three different hormones have been found to occur naturally in plants: auxin *a* and auxin *b* in higher plants, and heteroauxin in the fungi. Although chemically distinct, they are not yet known to differ in their effect on growth.

A few years hence the picture presented here will change materially. We have just started to work with a new tool that should aid in probing further the secrets of plant development. Every great surge of progress in our understanding of growth has come about from the discovery and use of just such a new tool. This augurs well for the future of our knowledge of chemical correlation in plants, and, indeed, for our understanding of plant morphogenesis as a whole.

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RESPONSES OF PLANTS TO HORMONE-LIKE SUBSTANCES

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My assignment concerns the work at the Boyce Thompson Institute with plant hormones and chemical compounds which induce a hormone-like response. The program committee was kind enough to have my paper preceded by one from Dr. Avery dealing with the historical phases of the subject. I will limit myself, therefore, to the work at the Institute. What I have to say involves also the work of two of my associates, Drs. A. E. Hitchcock and Frank Wilcoxon; plant physiologist and chemist, respectively. I wish to fully recognize the part they have taken in the work, though I shall not attempt to point out individual contributions. Dr. William Crocker, Director of the Institute, has also maintained a very active interest in our work on growth-promoting chemicals, especially as related to unsaturated carbon gases.

In recent years several terms have been used to designate growth-promoting substances (plant hormones, growth hormones, growth substances, growth regulators, auxins, etc.). As used in this paper, the following definitions will apply: *Plant hormones* are substances, produced by the plant and which exert a regulatory influence on growth and development of the organism. As far as green tissues are concerned, these "substances" have been shown to exist but not one has been chemically identified. Hormones are present in minute amounts and must not be confused with materials having a direct nutritive effect. *Natural growth substances* carries the same meaning as "hormone." *Auxin*, or hetero-auxin, is used to designate "Auxin A" or "B" or indoleacetic acid, which were extracted from urine, corn meal, etc. (but not green tissue) and assigned chemical formulae by Kögl. They are therefore classed with other known chemical compounds which induce hormone-like responses in plants. *Synthetic growth substances* are any chemical compounds which, when applied locally or otherwise, induce hormone-like responses in plants. They include compounds that cause bending, swelling, proliferations, and overgrowths of stems and leaves, and in some cases the induction of adventitious roots. As to form, they may be acids, salts, esters, or gases.

During the past few years, 32 growth-promoting substances have been reported. Among them are 14 acids, 11 esters, and four unsaturated carbon containing gases. Also salts of the various acids are effective.

The most important substances from a scientific standpoint are naphthaleneacetic acid, indoleacetic acid, indolebutyric acid, indolepropionic acid, fluoreneacetic acid, phenylacetic acid, ethylene, propylene, acetylene, and carbon monoxide. For practical plant propagation, naphthaleneacetic acid and indolebutyric acid are the most important.

The tomato plant has been extensively used as a test object when effective chemicals were being compared or when new compounds were tested for activity. Many other species, however, serve the purpose as well as tomato. Details of the tests will be mentioned later.

A simple method for applying substances locally is to mix a given amount of the chemical with a known quantity of lanolin (wool fat) and apply the preparation with a glass rod to the part of the plant to be treated. A one per cent mixture is usually convenient at the start. If this is found too strong (as would be the case with naphthaleneacetic acid) it can be readily diluted with pure lanolin. Other carriers, as paraffin oil, olive oil, etc., might be found more useful than lanolin for some purposes.

Water solutions of growth substances are effective over a wide range of concentrations from 1 part in 5,000 to 1 part in 1,000,000. The dilutions must be varied according to the substances and the uses to which they are put.

In 1933 three papers (9, 10, 11) reported that four unsaturated gases (carbon monoxide, ethylene, acetylene, and propylene) induced epinasty (due to accelerated growth on the upper side of the petiole) and initiated adventitious roots on stems and leaves of many species of plants. These responses involved cell enlargement, cell division, and the organization of cells for the production of adventitious organs. The gases were applied to the entire plant or to a single root or leaf with the result that the chemical moved into the tissue and spread throughout the plant, causing a systemic response (Fig. 1A). The gases were also dissolved in water and applied in solution with similar effects.

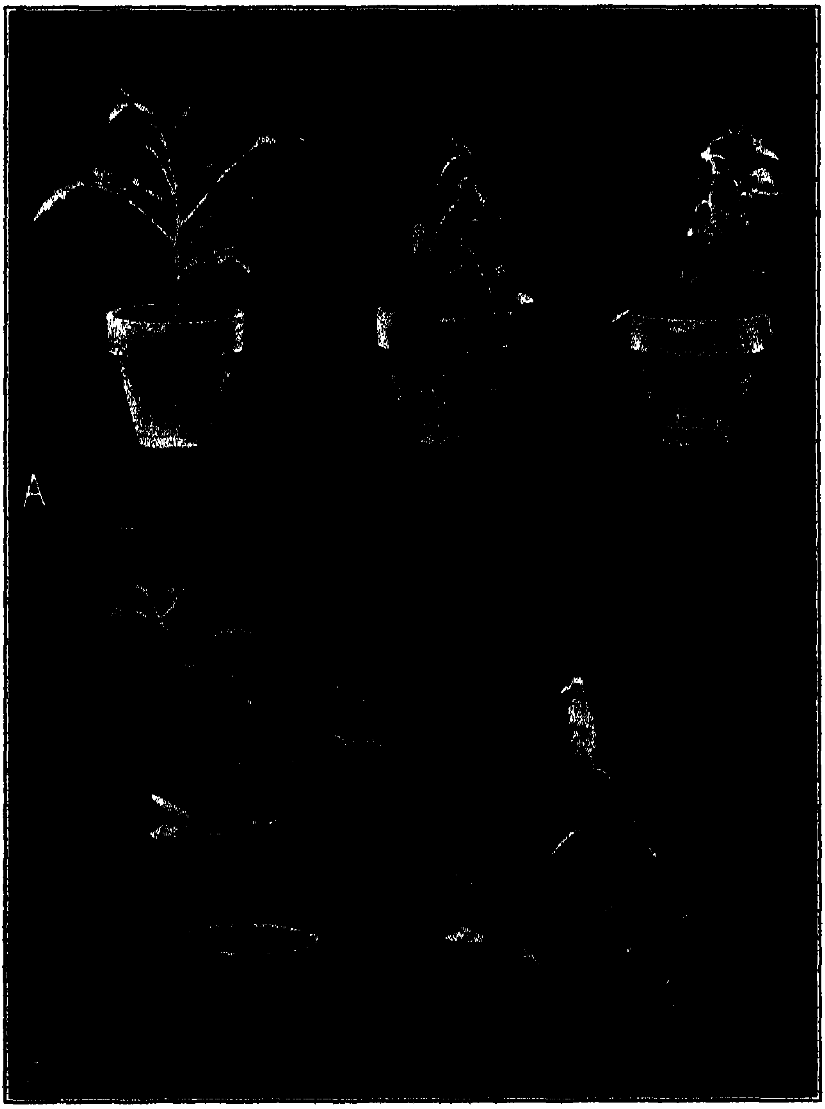

Figure 1. Tomato plants. A., Left, control; middle, treated with one part of ethylene gas to 500,000 parts of air. Photographed 24 hours later. Right, treated on the upper side of the petioles with a lanolin preparation containing 0.1 per cent naphthaleneacetic acid. B., Left, control; right, cut surface treated with 1.0 per cent naphthaleneacetic acid. Photograph taken eight days later.

Beginning in 1934 the responses induced by the simple compounds (gases) were compared with responses induced by more complex substances, ring compounds (2). Though administered in a different way, the end results were about the same for both groups of chemicals. The crystalline compounds have the advantage of being easily applied in water, oil, or lanolin, inducing either local or systemic responses.

The following are some of the responses to be considered: Local acceleration of growth causing bending of stems and leaves (epinasty); systemic responses vs. local; swelling and proliferation of treated tissue; cell division and induction of adventitious roots; acceleration of growth following retardation; and retardation of root elongation followed by increase in diameter and induction of adventitious roots.

When lanolin preparations of growth substances are applied to the upper side of a tomato petiole, growth is accelerated locally and the result is downward movement of the leaf (Fig. 1A). The degree of movement varies with the concentration of the substance and the age or condition of the leaf.

Similarly, if a growing stem is treated on one side with a low concentration, the growth rate is increased and the stem is caused to bend away from the treated side (negative bending). If the concentration is too high, growth is retarded and the stem bends toward the treated side (positive bending).

Local application of very low concentrations induces only a local response, but if high concentrations are used the substances are translocated and tend to induce a systemic response as shown by epinasty of leaves beyond the treated region. As with gas-treated plants, the upper side of the petioles respond first and, therefore, the downward growth of the leaf. The systemic effect is readily induced by injecting a water solution into the tissue or by watering the soil with a solution of the substance. To inject the substances it is well to use a glass tube holding 0.3 cc. and drawn to a capillary at one end. Insert the capillary into the stem and allow the contents to drain into the tissue. The time required varies with the plant, the weather conditions, and the time of day. Usually two to four hours are sufficient if the plant is in a light, dry, place. For this purpose use approximately 0.1 mg. of the substance per cc. of water. When the solution is added to the soil, use 10 to 40 mg. in 50 cc. of water, depending upon the activity of the substance and the size of the plant. An 8-inch high tomato plant in a 4-inch pot will respond when 20 mg. of indolebutyric acid in 50 cc. of water are used. Half of that concentration is sufficient for naphthalemeacetic acid or indoleacetic acid.

Bending responses can be detected within one to two hours after the substance is applied. The activity continues and the response is complete within six to ten hours. Within 48 hours another kind of activity, swelling of the tissue, becomes evident. This phase of the response is associated with cell division and the activity may continue until the stem breaks open or ruptures the epidermis. Proliferations and gall-like growth occur when some kinds of plants are used. These are sometimes compared with crown galls or tumors. They differ, however, in that they do not continue to grow long after the substance is removed. Crown galls continue to grow as long as living organisms are present, but malignant tumors of animals are not so regulated. The tumor seems to provide its own stimulus once initiated.

A third type of response becomes evident within five to ten days when adventitious roots begin to make their appearance. Stems, leaves, flower stalks, and young fruit can all be induced to form roots while the plant is intact. If the top of a growing plant is removed and the chemical applied to the cut surface, a crown of roots soon appears (Fig. 1B).

There is considerable variation in the root-inducing power of the growth substances applied to intact plants, naphthaleneacetic acid being the most effective and the phenyl compounds among the poorest. The latter often cause much swelling with few or no roots while indolebutyric acid may cause little swelling and many roots.

There is an important difference between the response of stem tissue and that of roots. Cells of growing stems can be increased in length by treatment with growth substances. That is the cause of bending when the chemical is applied unilaterally. Cells of root tissue on the other hand not only do not increase in length when treated, but are actually retarded by the substance. When aerial roots of Cissus are treated with comparable concentrations along one side with only a trace of growth substance, positive bending results. If the tip is treated the entire region of elongation is retarded. In other respects stems and roots respond very much alike. Following treatment there is evident swelling and increase in diameter and then within three to six days numerous branch roots appear. The same substances have been used to induce adventitious roots on roots and roots on stems. This raises the question whether there might be a group of chemicals, not now recognized, which have the power to induce shoots or other organs of plants.

Mention was made of the absorption of growth substances from the soil. The rate at which the chemicals were taken up the stem was detected by stem bending and epinasty of the leaves. There was evident variations with weather conditions as with transpiration and it was assumed, therefore, that with this method of application the substance traveled in the transpiration stream. If the rate of transpiration was reduced by increasing relative humidity or placing plants in the dark, the rate of movement of the substance from the roots was also reduced.

However, responses induced by lanolin preparations applied to the aerial parts were not influenced by atmospheric conditions in the same way. Darkness or high relative humidity favored absorption from lanolin preparations through the epidermis and longitudinal movement in both directions. Apparently, therefore, movement of these substances occurs also outside the transpiration stream.

In this connection it should be pointed out that growth substances can be absorbed from water solutions through the tips of the leaves. If the tip of a tomato leaf attached near the center of an eight-inch plant is placed in a solution of naphthaleneacetic acid (10 to 30 mg. per 100 cc. of water) or indoleacetic acid, epinasty of the treated leaf occurs within an hour or two. This response is soon followed by bending of the stem and epinasty of other leaves, both below and above the treated leaf. The movement downward, however, is more rapid than upward. When treating leaves in this way it was found best to break the epidermal hairs or otherwise damage the tissue to facilitate entrance of the chemical.

CONDITIONS AND FACTORS AFFECTING THE RESPONSE OF PLANTS TO GROWTH SUBSTANCES

It was evident from the first that varying the environmental conditions changed the capacity of plants to respond when treated with any of the several growth substances. Plants in different stages of maturity, or similar plants at different seasons of the year varied in their capacity to respond to treatment. Sunlight and complete darkness brought out some facts which should be considered.

A large number of six-inch tomato plants in four-inch pots were placed in the dark room with a temperature of 75° to 80°, and each day for a week several of the plants were subjected to a series of tests. The tests consisted of treatment of leaves and stems with lanolin preparations of growth substances; subjecting the plants to an atmosphere containing ethylene gas; placing plants in a horizontal position to induce the negative geotropic response (bending away from the earth).

The summarized results are as follows: The plants lost their capacity to respond (epinasty of leaves) to ethylene gas in three days, and to the growth substances in six to seven days. When placed in a horizontal position the plants failed to right themselves after the fourth day (Fig. 2A). At this time, however, the horizontal plants could be induced to turn upward if treated on the lower side of the stem with lanolin preparations of the growth substances (Fig. 2B).

Geotropic responses are assumed to be due to a redistribution of natural hormones in favor of the lower side (8). If this theory is correct, plants losing their capacity to grow upward presumably have lost all their natural hormones. Plants in this condition should make good test objects to determine which chemical compounds act like hormones and might therefore properly be called "growth substances." On that basis all of the naphthalene, indole, and phenyl compounds mentioned at the beginning of this paper could qualify (3).

It appears that growth responses involve a chain of essential compounds. If any one is missing there can be no growth. The plants in dark for several days lose their natural hormone (1) which has to do with geotropic response and, therefore, cannot right themselves when placed in a horizontal position. The growth substances have been substituted for the "missing link." It could be further assumed that if any essential elements, for example sugar, were absent there could be no growth until a satisfactory substitute was supplied. Perhaps the substitute could be another sugar different from the natural product.

There was some relation between the food storage organs and the length of time plants could tolerate darkness. Large tomato and tobacco plants lasted much longer than small ones. Plants with storage organs—dahlias, artichokes and potatoes—grown in the dark from the first, kept their capacity to respond to gravity and treatment with growth substances for 60 to 80 days (Fig. 2c).

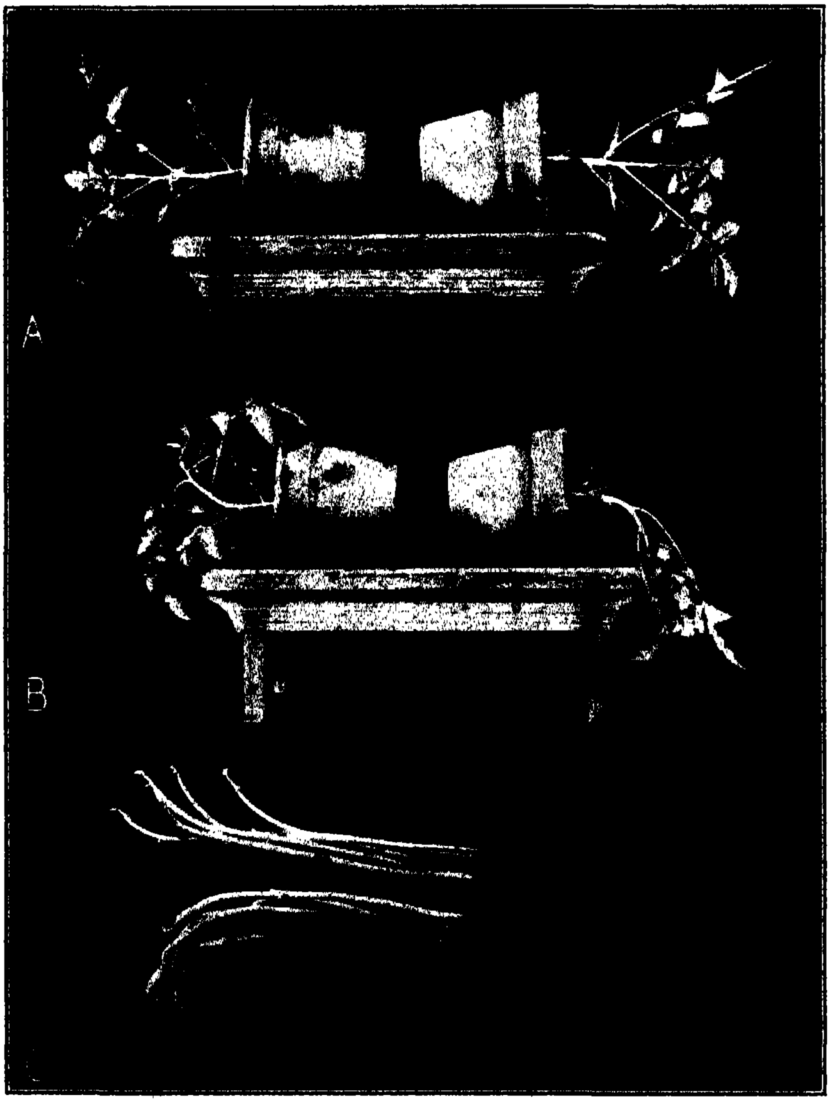

Figure 2. A., Tomato plants in the dark four days, then placed in a horizontal position and photographed 24 hours later to show loss of capacity to respond to force of gravitation. B., Same plants as in A. 24 hours after treatment with 1.0 per cent indolepropionic acid. Left, treated on under side; right, treated on upper side. C., Potato plants grown in dark for 25 days, then placed in horizontal position, at which time lower six shoots treated on upper side with naphthaleneacetic acid. Upper shoots left for controls show negative geotropism.

It appears, therefore, that light is not essential for the production of natural hormones in growing tissue if storage organs are present. On the other hand, small seedling plants (tomato and tobacco) soon lost their natural hormones if kept in continuous darkness. The rate at which small seedlings lost their hormones varied with the temperature. Plants kept at 50° F. for 10 days still responded to gravity ethylene gas and other growth substances while those at 80° lost their capacity to respond after four to six days. Transferred back to light these plants regained their capacity to respond to gravity and growth substances.

It is not clear from these data what part light plays in producing hormones in seedlings in contrast with the supply in plants having storage organs and grown in the dark.

PRACTICAL APPLICATIONS

The botanical laboratories will find many uses for growth substances.

In the search for natural hormones and synthetic compounds which induce hormone-like effects on plants, several different methods have been developed. The *Avena* method which employs the oat coleoptile as the test object is well known. This has been considered by some investigators as the standard method. To obtain reliable results with this procedure, it is necessary to use a standardized strain of oats, to maintain a constant temperature in a dark room with high humidity, and to become highly skilled in handling the equipment, conducting the experiments, and collecting the data. In fact the difficulties involved discourage all but the most persistent investigators. Another objection to the *Avena* test is that it measures only one of several growth responses induced by hormone-like substances—namely, the capacity of a substance to cause cell elongation. To satisfy all the requirements, a method should be capable of measuring cell enlargement, cell division, penetration, and the induction of new organs. At the present time no one method has been found that can fulfill all of these requirements.

The technique developed in the laboratory at the Boyce Thompson Institute makes use of the tomato plant though many other species can be satisfactorily used. No special skill is required. The chemical being investigated is mixed with lanolin or olive oil and applied to one side of the stem at the region of elongation and on the upper side of the adjacent petiole. If the substance is active the leaf bends downward and the stem bends away from the leaf thus increasing the angle between the treated parts. This response occurs within one to six hours. After a compound is found effective, dilutions are made and compared with a known standard which is usually α-naphthaleneacetic acid. A concentration of one part of this substance to 1,000,000 parts of lanolin will induce epinasty of tomato leaves.

The same technique serves also to test the root-inducing capacity of a substance for intact plants but higher concentrations are required. The highly active substances induce roots over a range of concentrations beginning with 0.001 per cent and going up to the toxic limit which is usually around 1.0 to 3.0 per cent.

The capacity of a substance to spread throughout the plant and thus induce systemic responses is determined with the use of lanolin preparations and water solutions. The first application of lanolin preparations serves for studying induced acceleration of growth causing bending from cell enlargement, cell division, penetration, systemic response, and production of adventitious roots. Responses involving retardation and various types of proliferation can also be determined. The water solutions are added to the soil of potted plants, injected into stems and leaves, and used for tests involving immersion of leaves. Also leafy cuttings of tomato are convenient test objects for quick response. If the basal end of a six-inch cutting is placed in a solution of an effective substance, induced epinasty of leaves becomes evident within an hour or two.

Plant propagation. To test the root-inducing capacity of substances to be used in connection with propagation of plants from cuttings, *Ligustrum* and *Euonymus* are generally used. They are usually available and both hardwood and summer cuttings respond readily. The basal ends of the cuttings are placed in water solutions of the substances for 24 hours and then planted in a rooting medium. The controls under this condition start rooting in 20 days. If the substances are effective the treated cuttings will have developed roots in 14 days.

The most important substance for propagating plants by cuttings is indolebutyric acid. Naphthaleneacetic is second and indoleacetic acid third in importance. The indolebutyric is effective over a wider range of concentrations than the other substances.

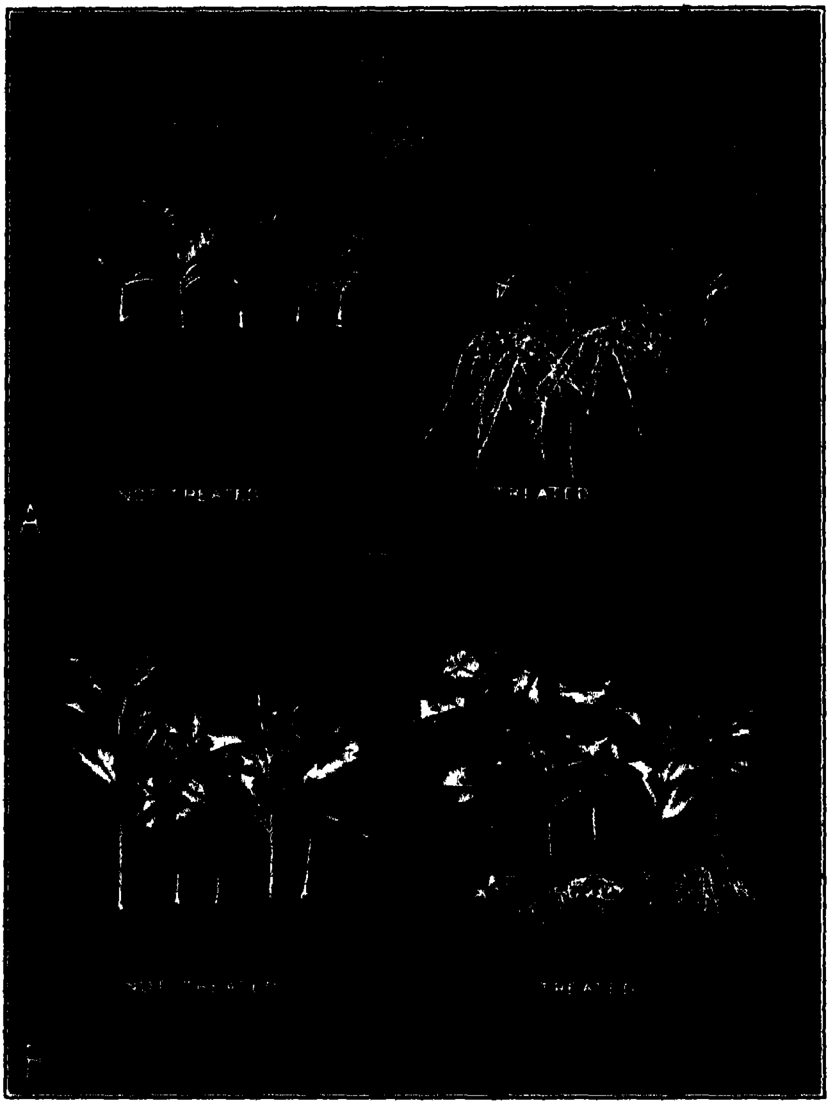

Figure 3. Cuttings treated with water solution of indolebutyric acid for 24 hours, then planted in the rooting medium. A., Taxus. B., Holly.

With the aid of this substance we have been able to hasten the rooting of species which are ordinarily propagated by cuttings and to induce roots on cuttings of species which will not root otherwise. An adequate root system can be quickly formed and the resulting plants readily established. Some of the difficulties encountered in the past with plants from cuttings concerned a meager root system. This phase of the problem can now be eliminated.

The question is often asked, do these chemically treated cuttings produce normal roots? The only answer I can make is that the resulting root system appears normal and after being planted in soil the new plant is readily established,

Approximately eighty-five genera, involving several hundred species and varieties, have been found to make satisfactory response when given the chemical treatment. Taxus and holly (Fig. 3) can be rooted in half the time required ordinarily for control cuttings. Both young and old wood work equally well. Roses and dogwood are among the most sensitive types responding in a very short time to low concentrations of the substance. Apples and pears vary with the variety. They do not respond when hardwood cuttings are used but several varieties can be propagated readily from treated greenwood cuttings. In general, leafy cuttings of all species respond better than leafless, hardwood types. The difficulty may be that the leafless cuttings do not take up the material from solution. However, it has been encouraging to find that many species respond when both hardwood and green cuttings are used.

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More Astronomy for the Millions

It is evident from the title and text that the author of this book has read the several previous attempts to make a knowledge of the universe available to the "millions." He has examined the results, found them wanting and turned his own efforts to rectifying the deficiency. His satisfaction in his work is one of the outstanding features of his book.

Judged objectively, "Astronomy for the Millions" is a poor book. It abounds in exclamation points and adjectives, such as "amazing," "incredible," "magnificent," and others of the Hollywood type. The sentence structure is frequently atrocious, lacking in subject or predicate or sometimes both. Paragraphs often begin with expletives and end in confusion. The author conveys the impression that he is striving to achieve clarity of exposition by raising his voice. He is given to the use of literary devices such as discovering the fragments of a diary written by a man who had made a trip to Mars. It does not appear that the device helps the understanding of conditions on the planet very much. It is in fact misleading because it allows the reader to believe that we know a great deal more about the Red Planet than is in fact the case.

"Astronomy for the Millions" is misleading in more than this one respect. There are several short passages that are open to question. Of the longer treatments, one of the most misleading is a discussion of the expanding universe in which the author does little to indicate that the observational evidence has not yet given full support to the theory. Hubble, an authority on the subject, even says that the data now available seem to show that the universe is **not** expanding.

The author, in short, tries too hard and stoops too much. Such a story would have been better told in forthright language of great simplicity.—C. E. Hesthal.

Astronomy for the Millions, by G. Van Den Bergh. xi+370 pp. New York, E. P. Dutton and Company, 1937. $3.50.

NERVOUS SYSTEM AND INTERNAL SECRETION

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Internal secretion has become a problem of widespread interest since an overwhelming array of facts has been found showing that hormones are the fundamental and indispensable instruments by which the functions of the animal body are regulated and coordinated. To a great extent life as a whole is integrated by hormones. Former discoveries in this field led, and with reason, to a growing belief that, as Sterling expressed it, chemical regulation is not only the older but also the more widespread and fundamental form of coördinatory mechanism.

This latter view eventually led to a lesser estimation of the nervous system, to which, up to that time, had been ascribed the preponderant influence as regulator of functions. Too, another factor has contributed for quite a time to studying internal secretion without regard to the central nervous system, namely, that hormones appear to act whether a tissue is innervated or not. Internal secretion apparently continues even after all connections between the nervous system and glands of internal secretion have been severed.

On the other hand, the question whether hormones had any influence on the nervous system has not received sufficient attention. This neglect was for a time justified, as first of all the better defined reactions of peripheral structures and functions had to be determined, especially as the results could be expressed in more or less quantitative terms. Most valuable and trustworthy information on the activity of hormones has been obtained in this manner.

Nevertheless, earlier observations had suggested a striking influence, especially of one gland of internal secretion on the central nervous system. From the very beginning of modern study of the thyroid gland it had been recognized that young individuals with varying deficiencies of the thyroid gland developed cretinism, characterized, among other features, by inferior intelligence and mental activity. Naturally this was taken as proof that the thyroid has an influence on the central nervous system. However, the question remains open whether mental disablement is not a secondary phenomenon due to the arrested development of the cells of the cortex of the brain. Also in young animals symptoms of mental inactivity become apparent following thyroidectomy.

To arrive at a more intimate knowledge of the relation between glands with internal secretion and the activity of the central nervous system investigation of the thyroid gland appears particularly significant, since it is especially adapted to study and has, in addition, an outstanding position as regards its influence on the central nervous system. Notwithstanding this situation we had to work out methods for quantitatively estimating this influence. It was necessary to state in exact units the intensity of the stimulus acting on the central nervous system as well as the intensity of a well-defined response. The postulated demands were fulfilled by various methods developed for our purposes in the Physiological Institute of the University of Berne.

I will begin with the reaction of the respiratory centre in the medulla. This is stimulated by CO_2. The strength of this stimulus can be quantitated by having an animal breathe air of either 20 or 40 mm. CO_2 tension. The response is then exactly measured by observing the amount of air breathed in one minute through a gasometer. When the increase of the minute volume of respiration of the normal animal inspiring these air mixtures is known, we inject the hormone of the thyroid gland, best in the form of thyroxin. The usual augmentation of respiration is increased but what is especially striking is the fact that three and a half hours after injection of thyroxin, this augmentation is already marked. It is the earliest response which thyroxin evokes, while the first metabolic effects do not appear before 24 hours. This time relation is significant as it shows that the primary effect of the internal secretion of the thyroid is on the central nervous system. After thyroidectomy the reaction is reversed and the excitability of the respiratory centre is much lower. The opposite changes in excitability after injection of thyroxin and after thyroidectomy are also noted if one records the frequency of respiration of animals subjected to raised environmental temperature; the increase, compared with the normal animal, is greater after thyroxin, and smaller after extirpation of the thyroid.

It is of interest that extirpation of the spleen acts in the same direction on the respiratory centre as an increase in the activity of thyroid gland. This suggests that as long as the spleen is in the body, it exerts an inhibitory action on the respiratory centre and therefore the withdrawing of this influence is equivalent to an augmentation of thyroid activity on the nervous system. This deduction is supported by the fact that injection of a purified spleen extract produces a relative inhibition. The antagonistic balancing influence of thyroid and spleen is not restricted, by the way, to the nervous system; it also appears in the regulation of peripheral functions.

The influence of thyroid secretion on the higher levels of central nervous system activity was studied by quantitative investigations of the reflex response to stimulations with light or sound. We subject, for instance, the eye of a rabbit to light of which the intensity, distance from the eye and duration are exactly measured. After the threshold value for contraction of the pupil of the given normal animal has been determined, thyroxin is injected. If this is repeated two or three times, the threshold value for eliciting the reflex is found to be greatly decreased; consequently, the sensitivity of this mechanism is increased. Guinea pigs react precisely to a high pitched sound with a rapid movement of the ear. This reflex is an interesting instance contrary to a current notion that reflex activity is necessarily subject to fatigue. In reality this reflex appears to be in a high degree indefatigable. For, if the stimulus is repeated every second, the animal will respond without fail for an hour or more with the rapid jerk of its ears. The intensity of the stimulus is easily measured by the pressure which is necessary to drive the air through a Galton pipe for attaining the threshold intensity of sound. The distance of the pipe from the animal is kept constant. Again after increasing experimentally the thyroid secretion, the animal becomes far more sensitive to sound while thyroidectomy greatly depresses its sentitivity.

Even those parts of the brain to which we ascribe the highest functions, namely, the cortex of the forebrain, can experimentally be recognized as affected by the thyroid hormone. Narcosis by ether, as used in surgery to make operations painless for the patient, is mainly a temporary inhibition of the highest centers of the cerebral cortex; in human beings the seat of consciousness. If the thyroid hormone is capable of sensitizing the cortex, we should expect in states of hyper- and hypothyroidism a different reaction towards narcotics than in the normal state. This expectation is readily verified under the condition that a narcotic is administered by a method that allows a quantitative estimation of the amount of narcotic substance necessary to produce narcosis under controlled conditions of application and time. The method we employed was to drive ether mixed with known amounts of air under constant pressure through stopcocks of graded dimensions and measuring the amount of ether used as soon as narcosis was attained. The latter value was remarkably constant for a given individual. Animals under the influence of increased thyroid hormone were far more resistant to narcosis than in the normal state. We should be justified to draw the conclusion that thyroid internal secretion raises the vitality of the higher parts of the brain, a conclusion, of course, not new to us, as intellectual deficiency is known to us from cretinism based on lack of thyroid activity.

At the present state of our knowledge the thyroid is outstanding in demonstrating the relation between nervous system and internal secretion. Less is known regarding the other glands of internal secretion, with the exception of the gonads. Loss of the latter does not alone extinguish the sexual functions, but also to a certain extent depresses the vivacity of certain of the nervous activities. What has frequently been viewed as a kind of rejuvenation is more probably a temporary reactivation of the nervous system by the introduction of appropriate sexual hormones. Perhaps if we are able to develop more refined methods to test the activity of the brain, we shall know more about the influence of the hypophysis and the adrenal glands on nervous activity, an influence which we are warranted to presume.

Notwithstanding the fact that glands with internal secretion are autonomic, a regulatory influence of the nervous system on their secretion must be postulated, as anatomy shows them to be richly inervated. Experimental investigation has given decisive proof of a regulatory nervous control of internal secretion. The evidence for the adrenal gland, insofar as adrenalin, the hormone of the medullary substance, is concerned, is clear cut. Stimulation of the splanchnic nerves, whether experimentally through induction currents or naturally by various reflexes, causes an output of adrenalin into the blood. Whenever through muscle work, or fear, rage and other emotions, greater demands are imposed on the organism, the central nervous system leads by natural impulses to a secretion of adrenalin. In this way, as Cannon ably has put it, the adrenal gland becomes one of the helpmates of the organism to overcome the stress and strain of life.

The frequency of diabetes has directed popular attention to the pancreas, which, by way of its islet cells produces insulin, the powerful regulator of carbohydrate metabolism. Previous to the discovery of insulin, my collaborator, Dr. de Corral from Madrid, showed that stimulation of the vagus nerve caused the level of blood sugar to become lowered, which is precisely, since we now know insulin, the reaction to increased secretion of this hormone. By employing more modern methods Zunz in Brussels has corroborated in a most convincing manner the nervous control of the regulation of carbohydrate metabolism by insulin.

The question of the nervous regulation of thyroid secretion was for a long time beset with peculiar difficulties. But they have been overcome since we have learned to use well-defined reactions of the thyroid internal secretion which take into consideration the time in which these reactions gradually develop. Absorption of fluid from the subcutaneous tissue of a lower extremity takes a certain time and it is of approximately the same duration whether the animal is in a cold or warm environment. This becomes different when the thyroid is denervated. The absorption time is then longer and an appreciable difference between cold and warmth appears. Evidently the regulation of absorption has become impaired. That this is exclusively due to the denervation of the thyroid is further demonstrated by the fact that the said difference is accentuated by thyroidectomy. Through the more refined method of thermoelectrical measurement of the temperature of the liver, we were able to show that after denervation of the thyroid, thermo-regulation in the liver as a response to cooling worked less efficiently and again that thyroidectomy magnified this inefficiency.

By way of the sympathetic nerves the intensity of the thyroid secretion is adjusted to the needs of the organism. I have before drawn attention to the influence of the thyroid secretion on the central nervous system. The influence just shown, in the reverse direction from the central nervous system on the thyroid, allows the suggestive inference, that central nervous system and thyroid are functionally linked together in shape of a circuit and that both are reciprocally interdependent. In consequence of this, when impulses from the nervous system stimulate thyroid secretion, the latter will lead to an increased activity of the nervous system and we shall see exactly as in the case of the heart, excitations incessantly going on in both directions, eventually leading to the diseased state of hyperthyroidism and nervous instability, until medical aid breaks the vicious circle.

It is appropriate to close my talk with the hypophysis, the remarkable gland at the base of the brain, unique in its dominating position over most of the glands with internal secretion and a ruler besides of important bodily functions of a general character. But even this powerful gland is subject to nervous regulation, emanating from pathways in the hypothalmus as recent fine work from American neurologists has demonstrated.

I thank the distinguished audience for the kind patience with which it has followed my lecture. It would be gratifying to have been in a little way successful in drawing a picture of the building up of life's regulation by nervous and hormonal control. Life shines out as a unity and as such is lavish in employment of means to its ends.

Entomological Terms

The standard work on entomological terminology published in 1906 and known as Smith's Glossary (Explanation of Terms Used in Entomology) has been completely revised and rewritten. The original volume contained about 4300 terms while the revision contains nearly 12,000 definitions. The science of entomology is a much broader field today than it was over thirty years ago when the original volume was written. The revision has brought up to date the modern as well as the original usage of terms, and includes terms from many related scientific fields. Some of these fields closely allied to entomology and concerned in the revised glossary are: chemistry, physics, botany, zoology, medicine and medical entomology. Various phases of these are also included such as cytology, physiology, genetics, ecology, morphology, embryology, development and taxonomy. A few mathematical terms are also included. Many of the terms are defined according to the commonly accepted usage. Special terms applicable to restricted groups are given and in such cases the originator of the term and his definition are given. There are two appendices, one of Latin abbreviations and the other of arbitrary signs and symbols used in entomology. Nine plates of various structures are included, three of which appeared in the original volume. A bibliography of the most important references is also included.

The revision represents an enormous amount of work on the part of the author. The book is well bound and printed on good quality paper in legible 10-point type. The binding is said to be of water-, dirt- and insect-proof cloth.

The new volume will serve as the standard reference book on terminology for entomology and closely related sciences for years to come. Every entomologist should have a copy to refer to before attempting to concoct some new term, or give a term now in use a new meaning.—R. H. DAVIDSON.

A Glossary of Entomology (Smith's "An Explanation of Terms Used in Entomology") revised and rewritten, by J. R. de la Torre-Bueno. ix+336 pp. Brooklyn, N. Y., The Brooklyn Entomological Society, 1937. $5.00.

THE GASTROINTESTINAL HORMONES OR AUTACOIDS

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INTRODUCTION

It is an evident fact that bodily processes are subject to excitation and inhibition. The chief agencies through which the bodily processes are augmented and retarded, or controlled, are: (a) the nervous system and (b) the hormone or autacoid secreting cells or organs. Nerves may effect muscle tissue so that it contracts or relaxes, or secretory cells, such as the salivary glands, so that their rate of secretion increases or decreases. Hormones or autacoids also act to augment or to retard bodily processes.

The hormones have been called autacoids, meaning self-remedial substances, because they act much like drugs or remedial agents. It is believed that two sorts of autacoids exist functionally, the hormones (to excite), which augment bodily processes, and the chalones (to inhibit), which retard bodily processes.

The autacoids are secreted into the blood and/or lymph by glands without ducts, in contrast to such glands as the salivary glands, whose secretion is drained externally into the mouth by ducts. Hence, the terms "Ductless Glands" and "Glands of Internal Secretion" are applied to the autacoid producing glands. The expression "Endocrine Glands" is also used, the word "endocrine" meaning to separate within.

Since, in the gastrointestinal tract certain food substances excite the secretion of gastric and pancreatic juice, we refer to these substances as "secretagogues." Secretagogues are substances which are present in food or which arise from the digestion of food. They stimulate gastric and pancreatic secretion. As will be noted later secretagogues may excite secretion by acting locally on the lining or mucosa of the stomach and intestine or possibly by being absorbed into the blood stream. Secretagogues are not hormones, since they are not formed by the living cells of the body, but are present in or result from the digestion of food. Any blood borne or circulating agent stimulating or depressing bodily activities is called a "humoral agent" whether it is a hormone or secretagogue, or substances of unknown nature.

SALIVARY GLANDS

All the evidence shows that the secretion of saliva is increased or decreased through a nervous mechanism. When food is placed in the mouth saliva flows because sensory nerve impulses pass to the brain and excite a salivary center (medulla), from which secretory nerve impulses pass to the salivary glands causing them to secrete. The contact of food with the oral mucosa does not cause the cells of the mucosa to secrete a hormone into the blood. For example, if lemon juice is placed in the mouth of a dog, saliva flows copiously. If the nerves to the salivary glands are cut one day and then lemon juice is applied to the mouth the next day, saliva is not formed. When extracts of the oral and pharyngeal mucosa are made and then injected intravenously or subcutaneously, the salivary glands are not stimulated.

The situation is different, however, in the case of the stomach, pancreas and liver. It is interesting that, whereas, the salivary glands appear to be controlled solely by nerves, the stomach is controlled by nerves and autacoids. Secretion of pancreatic juice and bile are controlled chiefly by autacoids and humoral (blood borne) agents. Nerves play a minor role in the formation of the latter two secretions.

GASTRIC SECRETION

The secretion of the acid gastric juice may be divided into three phases when one considers the point at which the stimuli are acting. These phases are (a) the cephalic phase, (b) the gastric phase, and (c) the intestinal phase. When food is seen, smelled or tasted in the presence of appetite, nerve impulses pass to the brain and then to the stomach by way of the vagus nerves causing the socalled "psychic" secretion of gastric juice. This phase is entirely nervous. The gastric phase is initiated by distension of the stomach and by the secretagogues in the food or the secretagogues produced by the gastric digestion of food. Whether distension of the stomach or the contact of secretagogues with the lining of the stomach excite secretion by stimulating the local enteric nervous system in the stomach wall or by causing a hormone to be produced is not known. Both may be concerned. It is known that secretagogues probably do not act in the stomach by being absorbed (3). The intestinal phase of gastric secretion is initiated by secretagogues acting on the mucosa of the intestine. Whether they act by causing a hormone to be produced or by being absorbed into the blood is not certain. It is possible that they may act by being absorbed into the blood (3).

It has been established that a humoral mechanism (agents such as a hormone or secretagogues) for stimulating gastric secretion exists. This was first shown (1, 4) (Ivy and Farrell) by auto-transplanting a small pouch of the stomach beneath the skin. When such an animal is fed, the transplanted pouch secretes acid gastric juice. Hence, when the animal ate, some substance or substances passed into the blood which stimulated the transplanted pouch. Whether the humoral or blood borne substance is of the nature of a hormone or of the nature of secretagogues is not certain.

An acid, saline, or alcoholic extract of the mucosa of the pyloric portion of the stomach, when injected subcutaneously, stimulates gastric secretion. The active principle of such extracts is called gastrin or the gastric hormone. Histamine in crystalline form has been isolated from such extracts, and the evidence indicates that histamine is the sole secretory excitant in such extracts (5). It cannot be concluded, however, that histamine is the gastric hormone, (a) because it has not been shown clearly that the histamine content of the blood increases after eating, and (b) because it has been reported that a substance has been dialyzed from the blood of a fed animal which on subcutaneous injection stimulates gastric secretion but does not depress blood pressure on intravenous injection like histamine.

Histamine is now frequently used in man to test the ability of the stomach to secrete acid.

PANCREATIC SECRETION

It is known that nerves are present in the vagus nerve trunks which excite and inhibit the formation of pancreatic secretion. Nerve fibers are present in the splanchnic nerve trunks which when stimulated cause a decrease in blood flow to the pancreas and a decrease in the formation of pancreatic juice. A "psychic" secretion of pancreatic juice occurs, but is relatively small in volume (5–10 cc., rarely more).

The principle mechanism which has been demonstrated to exist for the stimulation of pancreatic secretion when a meal is ingested is the elaboration of the hormone secretin. This hormone is produced when dilute acids, fatty acids, soaps and peptones contact the upper intestinal mucosa.

The discovery of this hormone by Bayliss and Starling in 1902 constitutes one of the major historical events in the field of Endocrinology. To stimulating principles, such as secretin, Starling (7) applied the term, hormone. The essential observations made by Bayliss and Starling were as follows: It had been known for sometime that dilute acid applied to the duodenal mucosa would cause the pancreas to secrete. This secretion was thought to be excited by a nervous reflex, and Bayliss and Starling desired to test this theory. They found that application of acid to the duodenum after the nerves to the pancreas had been sectioned still caused the gland to secrete, and that acid injected intravenously did not. They then made acid extracts of the duodenum and found that such extracts on intravenous injection stimulated the pancreas to secrete. It was then shown that when the circulation of two dogs was connected and acid placed into the duodenum of one, the pancreas of both secreted. Later it was shown that acid applied to an autotransplanted loop of intestine caused an autotransplanted portion of the pancreas to secrete (8). The possibility that secretagogues, after being absorbed into the blood, stimulate the pancreas, has been shown to be improbable (8a).

Purified preparations of secretin have been injected into normal human subjects (9). The secretion of the pancreas was, of course, stimulated. Secretin has apparently been crystallized (10); secretin crystals have also been prepared in the author's laboratory (11). From 0.016–0.008 mg. of the secretin base, from which crystals of secretin picrolonate were made, is adequate to stimulate the pancreas of dogs.

It is of interest that crystalline secretin stimulates the liver to secrete bile (12). The crucial experiment proving this was performed on animals deprived of their pancreas and gastrointestinal tract, so that the increase in flow of bile could not be secondary to increased activity of the pancreas and intestine. The cholagogue action of secretin, however, is not as marked as that of bile salts.

GALL BLADDER

Nerves pass to the gallbladder, but when stimulated only a small and variable amount of contraction occurs. It now appears to be established that the hormone cholecystokinin is the chief cause of gallbladder contraction and evacuation. This hormone is produced when dilute acids and fatty acids contact the duodenal mucosa. The essential facts demonstrating the existence of such a hormone are as follows: Extracts of duodenal mucosa have been made and injected into human and canine subjects; the gallbladder contracted and evacuated. Further, if the circulation of two dogs is connected and acid is placed in the duodenum of one, the gallbladder of both animals will contract. The intravenous injection of acid or of finely emulsified fat or chyle does not cause the gallbladder to contract. This shows that the absorption of acid or the products of the digestion of fat do not act as humoral agents for gallbladder contraction and evacuation.

This hormone is closely related to secretin chemically; but the two may be separated by an appropriate chemical procedure (12a).

ENTEROGASTRONE

Neutral fat inhibits gastric secretion and motility. This has been known for many years. It was formerly believed, however, that when fat contacted the stomach and duodenum the gastric activities were reduced by a nervous reflex. We now know that this inhibitory action of fat is due to the chalone enterogastrone, although the possibility that nerves are also concerned has not been entirely ruled out.

The essential facts showing that enterogastrone exists are as follows: When a small pouch of the stomach is transplanted beneath the skin and a balloon is inserted into the pouch so as to record its movement, it is found that the movements are markedly diminished a few minutes after fat is placed into the duodenum (13). The same is true for the acid secretion of the transplanted pouch (14). A concentrated solution of glucose or cane sugar acts similarly to fat. Gastric secretion and motility are not inhibited when finely emulsified fat or chyle is injected intravenously. This shows that it is not the absorbed food fat circulating in the blood that causes the inhibition of the movements and secretion of the pouch. Hence, the inhibition must be due to some specific substance or chalone secreted by the duodenal mucosa into the blood. Further, extracts of duodenal mucosa have been made which, when injected intravenously or subcutaneously, inhibit gastric secretion and motility (21).

The enterogastrone preparations made to date are not toxic, but they are not sufficiently "pure" to use in man. When the chalone has been prepared in a sufficiently "pure" or concentrated form, it may prove to be of value in the management of patients with "peptic" ulcer.

OTHER GASTRO-INTESTINAL HORMONES

Incretin: Rather strong presumptive evidence indicates that the duodenal mucosa produces a hormone which stimulates the islet cells of the pancreas to secrete insulin (1). It also appears to have a direct hypoglycemic property, since it lowers the blood sugar level in depancreatized animals (15, 16).

Enterocrinin, the hormone for the stimulation of intestinal secretion: When one observes the secretion of a loop of intestine which has been transplanted beneath the skin, it is noted that a copious flow of intestinal juice from this loop does not occur after feeding the animal (17). Closer study, however, indicates that some increase in the volume of secretion and output of enzymes occurs (18). A preparation of the intestinal mucosa has now been made free of blood pressure depressing substances which on injection increases the formation of intestinal juice. This hormone is called enterocrinin (Nasset).

Enterocin, the gastro-intestinal motor hormone: The possible existence of a hormone produced by the intestinal mucosa which augments gastro-intestinal tone and motility during digestion has been suggested by a number of observers (1). Although the motility of a transplanted loop of intestine is not definitely increased after the ingestion of a meal, closer analysis may show that it is. Preparations (1) of intestinal mucosa have been made which on injection augment intestinal motility (19). The active principle (the author calls this principle enterocin) has certain chemical properties related to secretin, but is not identical with it (20). It is not related to acetyl choline because its motore effect is not antagonized by atropine.

Concerning an erythropoietic hormone, it has been suggested that the gastrointestinal mucosa produces a hormone which is related to erythropoiesis. Little or no evidence exists to substantiate such a suggestion. The *desiccated* stomach, duodenum and colon of the pig is active in the management of pernicious anemia. But, this is probably due to the presence of an enzyme (intrinsic factor of Castle) which reacts with substances in the cells of the gut wall to produce the active erthropoietic substance. During life it is believed that the enzyme is secreted into the gastric and intestinal juice, and acts on certain foods, such as meat, to produce a substance which is absorbed into the blood and is used by the bone marrow to produce erythrocytes.

SUMMARY

From this brief review it is clear that the mucosa of the gastrointestinal tract is a veritable storehouse of autacoids. Seven or more hormones may be produced. The existence of three, namely, secretin cholecystokinin and enterogastrone, may be considered as established. The evidence is strongly presumptive for the existence of three others, namely, gastrin, incretin, and enterocrinin. Good physiological evidence for the existence of enterocin has not been produced.

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THE PROLONGATION OF INSULIN ACTION

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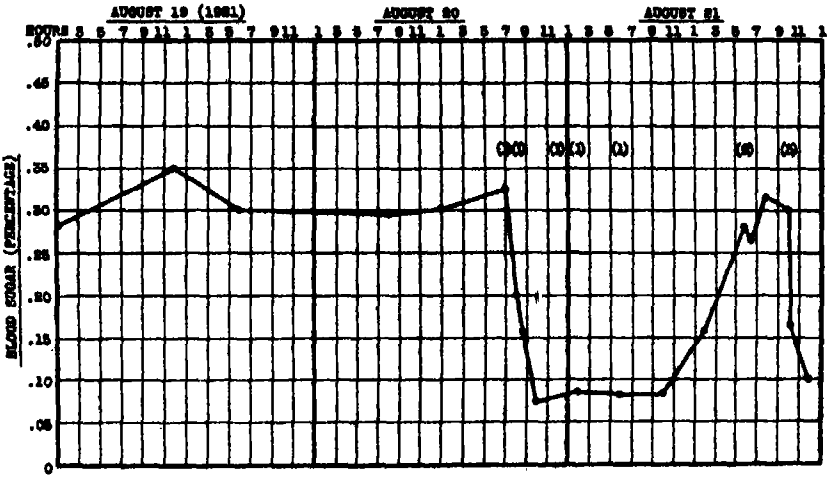
As an introduction to the consideration of the different forms of insulin, which will be discussed later, a few remarks may be made about the anti-diabetic material which was available in 1921. The administration of an effective dose of this material caused a fairly prompt fall of the blood sugar to a low level. The action was maintained for an appreciable length of time (Fig. 1). It is readily apparent to physiologists, who have worked with various preparations of insulin, that the crude material available 16 years ago had a much more prolonged action than the more highly purified preparations. While there is considerable difficulty in making an accurate comparison of materials used in 1922 and, let us say, in 1930, many clinicians also agree that the crude preparations exerted a much more prolonged effect than the solutions of the purified insulin. The removal of impurities decreased the incidence of local reactions at the site of the injection but did not improve insulin as a specific therapeutic agent.

Insulin was available in a very satisfactory state of purity before the substance was isolated in crystalline form. The preparation of the crystals was, from the chemical viewpoint, an extremely important landmark in the history of the development of the subject. This was accomplished by Abel, Geiling, Rouiller, Bell and Wintersteiner in 1927. The crystals occur in several forms and are to some extent interconvertible. The recent work of my colleague, D. A. Scott (1935, 1936), on the rôle of zinc in the crystallization of insulin has placed the preparation of these crystals on a more scientific basis. It is now a relatively easy matter to obtain large amounts and a fair yield (75 per cent or higher) from suitable amorphous material. The crystalline material was termed by Scott "zinc insulinate." Other metals may also be used in the preparation of the crystals and these combine with insulin in amounts which are proportional to their atomic weight. The average ash content of each insulin salt is proportional to the atomic weight of the metal it contains. This indicates that the crystals contain the metals as chemically combined constituents and not as impurities. Scott and Fisher (1935) have found that if the molecular weight of insulin be taken as 20,000 each formula weight of insulin combines with 1.4 formula weights of cadmium, with 1.5 formula weights of cobalt and 1.6 formula weights of zinc. If the molecular weight of insulin should be 40,000 one formula weight would therefore combine with approximately three formula weights of the metals. Svedberg, using his ultracentrifuge technique, has suggested 35,100 for the molecular weight of insulin and Crowfoot, on the basis of X-ray studies, a value of 37,200.



Effect of insulin on the blood sugar curve of a depancreatised dog (redrawn from Banting and Best). (1) Injection of extract of degenerated pancreas; (2) extract after incubation with pancreatic juice; (3) extract incubated without pancreatic juice. Blood sugars by Myers-Bailey modification of Lewis-Benedict method.

FIGURE 1

The chemical structure of these crystals of insulin has attracted a great deal of attention. This is not surprising since there are relatively few crystalline proteins which can be so readily assayed. An appropriate idea of the potency can be obtained when only a few milligrams of the material are available. There is an abundance of evidence that the crystalline material is protein in nature. Eight amino acids have also been isolated—cystine, tyrosine, arginine, histidine, lysine, leucine, glutamic acid and phenylalanine. Others are quite likely present. In the search for the active groupings in the molecule attention has been directed at the NH_2 group and the disulphide linkages. Destruction of the amino group irreversibly inactivates insulin. When the disulphide grouping is reduced to the sulphydryl the specific activity is lost—some investigators believe irreversibly while others think that a partial inactivation which can be reversed may be produced. An insulin-plastein may be formed when the products of peptic digestion of insulin are allowed to interact under certain conditions but this, as Scott considered likely before he performed the experiment, possessed no anti-diabetic activity. The complexity of the insulin molecule makes the possibility of synthesis remote.

The international yardstick for insulin is the new crystalline standard. Fifty grams of crystals were prepared in the Connaught Laboratories by Dr. Scott and presented to the Health Organization of the League of Nations by the Insulin Committee of the University of Toronto. The potency of the new standard was compared to that of the old amorphous preparation in a number of laboratories. The results were submitted to representatives of the National Institute for Medical Research, the University of Copenhagen and the University of Toronto (represented by Sir Henry Dale, Professor August Krogh and the writer). A recommendation was made that a value of 22 units per mg. be assigned to this new standard. It was felt that this would not change the strength of the unit. This recommendation was accepted by the Health Organization of the League of Nations (1936). The unit of insulin is, therefore, defined as the activity contained in 1/22 of a mg. (0.045 mg.) of the new International Standard.

IMPROVING INSULIN AS A THERAPEUTIC AGENT

The advances recently made in this field have prompted me to discuss it in some detail.

Various efforts were made in 1922 and 1923 to find a means of administering insulin by the enteral route. Very little success was secured, and if we now take all the reports on this problem into account, the situation is approximately as follows: Insulin is destroyed by the enzymes of the stomach and small intestine. Small amounts of insulin may be absorbed from the small intestine, particularly in young animals when very large doses are given. The rate of absorption is not predictable. There is no appreciable absorption from the large intestine. The situation with respect to the absorption of insulin from other mucous membranes is not more promising. An anti-diabetic effect can be observed when an insulin solution is inhaled, but results of practical value have not been secured. A very little insulin may be absorbed through the skin when vigorously rubbed in with a lanoline base.

It is well known that the anti-diabetic hormone is rapidly absorbed when given intraperitoneally, intramuscularly or subcutaneously. The rate of action of purified insulin is only slightly less when given subcutaneously than when administered into a vein, and intramuscular injection does not appreciably delay absorption. We can, therefore, restrict our discussion very largely to the question of modification of the rate of action of insulin which is administered subcutaneously.

As stated above there is an abundance of evidence to show that crude insulin exerts a more prolonged effect than the purified material. It is also well established that a given amount of insulin administered in several small doses exerts a greater effect than when the same amount is administered in large doses. This effect is due, probably, to the relatively large amount of insulin excreted or destroyed when the large doses are employed. These facts have stimulated investigators to attempt to secure the prolongation of the absorption of insulin from the subcutaneous tissue spaces. The first report of an attempt to do this was that of Burgess, Campbell, Osmán, Payne and Poulton (1923), who used insulin in gum arabic solutions. These investigators secured a definite prolongation of insulin action in diabetic patients and in experimental animals. Similar results were obtained by de Jongh and Laqueur (1925). Leyton (1929) convinced himself of the efficiency of insulin solutions mixed with certain oils. He was able to give larger doses, and apparently expected the use of oily suspensions of insulin to become general. Surányi and Szalai (1930) obtained a prolonged action and less frequent hypoglycaemic reactions when insulin was mixed with lecithin emulsions. Skouge and Schrumpf (1932) confirmed the lecithin results and found, as might perhaps be expected, that no extension of the insulin effect was obtained when the mixtures were given intravenously. They found it possible to administer subcutaneously large doses of insulin in lecithin without the production of hypoglycaemic reactions. Several groups of investigators—Wermer and Monguió (1933) and Clausen (1934)—attempted to prolong the action of insulin by administering pituitrin or epinephrin with the insulin solution. Little success attended these efforts.

Apparently the first attempt to modify the action of insulin by the use of metals was that of Bertrand and Mâcheboeuf

(1926). These investigators reported a very definite extension of insulin action when cobalt and nickel were added to the insulin solutions. This report led to the development of a controversy, and the findings have not been generally confirmed. We must not lose sight of the fact, however, that Bertrand and his collaborator were the first to suggest the use of a metal in this connection. The blood sugar curves which Maxwell and Bischoff (1935) have published appear to indicate that basic ferric chloride definitely slows the absorption of insulin. These investigators have used other metals including zinc in their studies of other hormones.

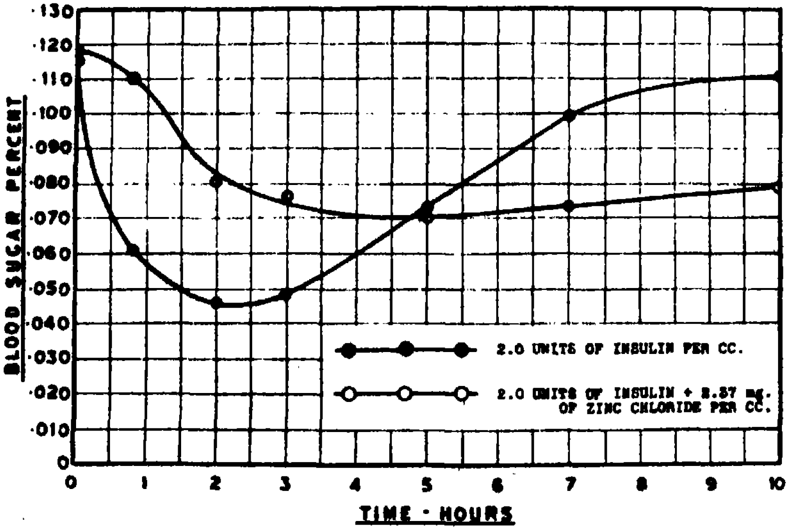


FIGURE 2. (From Scott and Fisher.)

Scott and Fisher were led to a study of the action of zinc salts on the rate of absorption of insulin by the findings referred to above, that zinc, or some closely related metal, was an essential component of crystalline insulin. The addition of the appropriate amount of zinc to insulin solution definitely delays the absorption of insulin. It is possible that the zinc forms a compound between the insulin and some component of the tissues, or that the zinc solution delays the absorption of the insulin by an astringent action or by some other mechanism. Scott and Fisher have reported very définite findings in rabbits (Fig. 2), and Dr. Kerr, working under my general direction, has confirmed their findings in the dog (Fig. 3). Dr. Walter Campbell in Toronto and Dr. Rabinowitch in Montreal have recently used zinc insulin in diabetic patients. A prolonged insulin effect has been observed.

PROTAMINE INSULIN

This brings us to a consideration of protamine insulin which has been used with very considerable success for more than two years by Hagedorn (1936) and his colleagues in Copenhagen. The chemical background of this ingenious procedure for delaying the absorption of insulin is most interesting and I will now digress for a moment to discuss it.

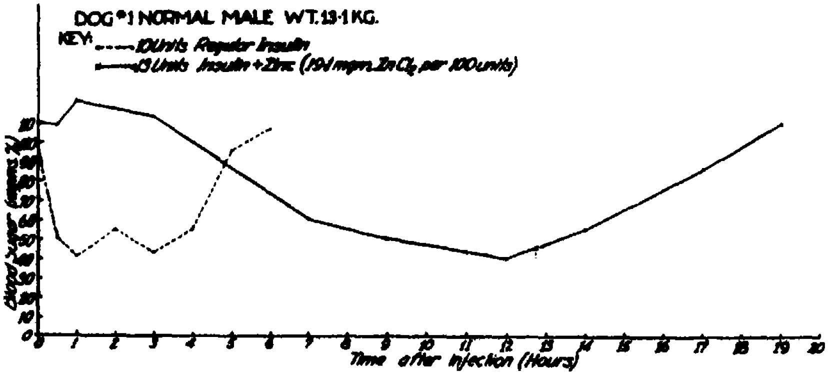


FIGURE 3. (From Kerr and Best.)

In 1868 Friedrich Miescher began an investigation of the chemistry of cell nuclei. This work, conducted in Hoppe-Seyler's laboratory, showed that proteins of acidic character containing phosphoric acid were present in nuclei of pus cells. Later he found these nuclions of nucleic acids in combination with basic substances in the sperm of salmon. He named the basic substances protamines. Some sixteen years later Kossel detected another type of basic substance in combination with nucleic acid. These were later shown to be similar to but somewhat more complex than the protamines. They are now called the histones. Kossel also isolated a protamine from the sperm of the sturgeon, which resembled but was not identical with the base from salmon sperm. Protamine was adopted as the general name for these bases while each separate one was called after the family name of the fish from which it was secured—thus sturine (sturgeon) etc. This protamine contains arginine, lysine and histidine, and is one of the triprotamines. Sturine also contains alanine and leucine. Clupeine obtained from herring sperm is a monoprotamine and contains arginine as the only basic constituent. Alanine, serine, an aminovaleric acid, and proline were also present. Salmine is also a monoprotamine and contains serine, aminovaleric acid and proline as well as arginine. Hagedorn and his colleagues have prepared a new protamine—probably of the mono- variety—from the sperm of Salmo irideus (salmiridine) and they have used this in their clinical experiments, with protamine insulin.

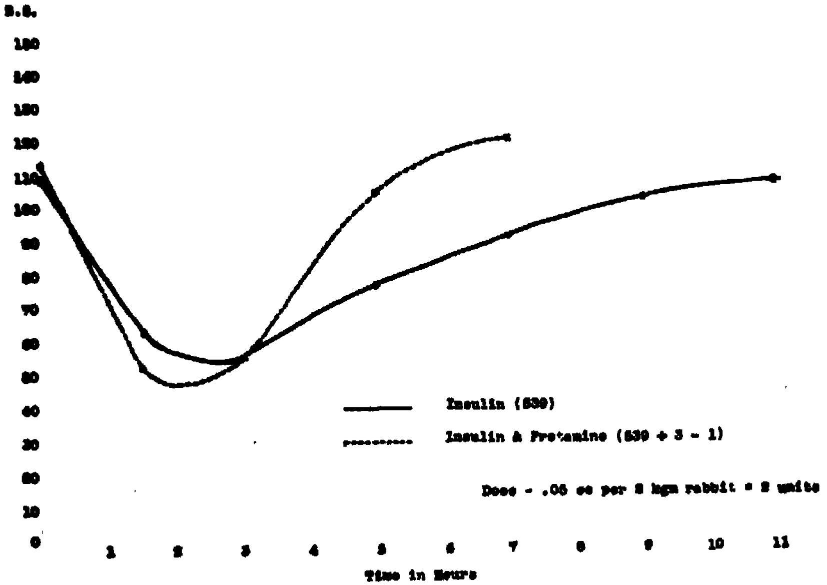


FIGURE 4. (From Scott and Fisher.)

Proteins are known to combine with the so-called protamines. The compounds are soluble at a certain hydrogen ion concentration, but insoluble at others. Hagedorn and his collaborators have very ingeniously taken advantage of this fact and have demonstrated beyond doubt that the compound of insulin and protamine is a very effective therapeutic agent in certain cases. A clear solution of protamine is added to insulin. The protamine is dissolved in a buffer solution of such a composition that the hydrogen ion concentration of the insulin-protamine mixture is approximately pH 7.2. At this pH the insulin-protamine compound is insoluble and forms a flocculent precipitate. If the vial containing the mixture is shaken and the suspension administered, the insulin is slowly liberated in the tissues and a prolonged anti-diabetic effect is exerted. That this is due to slow absorption has been demonstrated directly by Beecher and Krogh (1936) who watched the rate of disappearance of regular and protamine insulin from the tissue spaces. The effect of protamine insulin on rabbits or dogs is easily demonstrated (Figs. 4 and 5).

It has now been agreed by most diabetic specialists that protamine insulin has certain advantages over regular insulin in many cases of diabetes. The advantages are as follows:

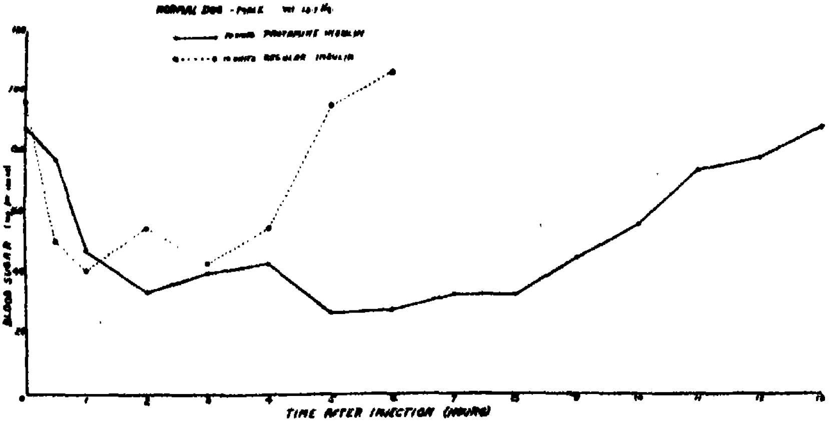


FIGURE 5. (From Kerr and Best.)

(1) The duration of the anti-diabetic effect is longer with protamine insulin than with the regular product. The number of injections required is, therefore, reduced. (2) The blood sugar curve is more regular and does not show the high peaks and marked depressions which are often observed with the regular material. (3) The ketosis is reduced when protamine insulin is used. (4) There are fewer hypoglycaemic reactions. (5) The patients feel better.

ZINC AND PROTAMINE INSULIN

When the protamine solution is mixed with the insulin and the insoluble precipitate formed, the resulting suspension of protamine insulin is not stable indefinitely. It has been found in the Connaught Laboratories and in the Insulin Committee's testing department that in some cases after a few days a portion of the material sticks to the sides of the glass vial (Fig. 6) and that it is impossible to secure samples of uniform potency. It has been found by Scott and Fisher that this situation is corrected by the addition of a small amount of zinc to the protamine insulin mixture. The zinc in some way stabilizes the suspension and prevents it sticking to the glass vial. If this were the only effect of zinc it would be a very significant contribution but there are grounds for belief that zinc plays a rôle in the formation of a protamine insulin compound. Thus Scott and Fisher showed (1936) that when preparations of insulin and protamine from which inorganic material has been in large part removed were mixed a prolonged anti-diabetic effect was not secured. If, however, a small amount of zinc was present in this mixture, a slow absorption of insulin and a prolonged action were consistently produced. These results on rabbits have been confirmed by Kerr and Best (1937) on dogs. (Fig. 7). This compound of protamine and insulin to which zinc has been added has been named by the Toronto group "protamine zinc insulin." The use of zinc has made it possible to distribute the preparation in one vial. The suspension is stable for at least six months and perhaps for much longer periods of time. The protamine used in the Connaught Laboratories has been prepared from the mature testes of several species of British Columbia salmon, namely, spring salmon (Oncorhynchus tschawytscha), cohoe salmon (Oncorhyncus kisutch) and the steelhead (Salmo gairdneri). These products are quite as satisfactory as those secured from rainbow trout (Salmo irideus) and are readily available in large quantities.

"FREE INSULIN" IN THE PROTAMINE ZINC INSULIN MIXTURE

Some clinicians have raised objections to the use of protamine insulin and protamine zinc insulin on the grounds that they do not exert their effects with sufficient rapidity. This has been overcome by the administration of a small amount of regular insulin with the protamine zinc insulin mixture. Quite recently a preparation, made by Fisher and Scott, which contains in addition to protamine zinc insulin a certain proportion of "free insulin," has been tested by Kerr and McCutcheon under my general direction in the Department of Physiology. It has been found that a rapid effect comparable to that obtained with regular insulin is secured and, further, that a prolonged

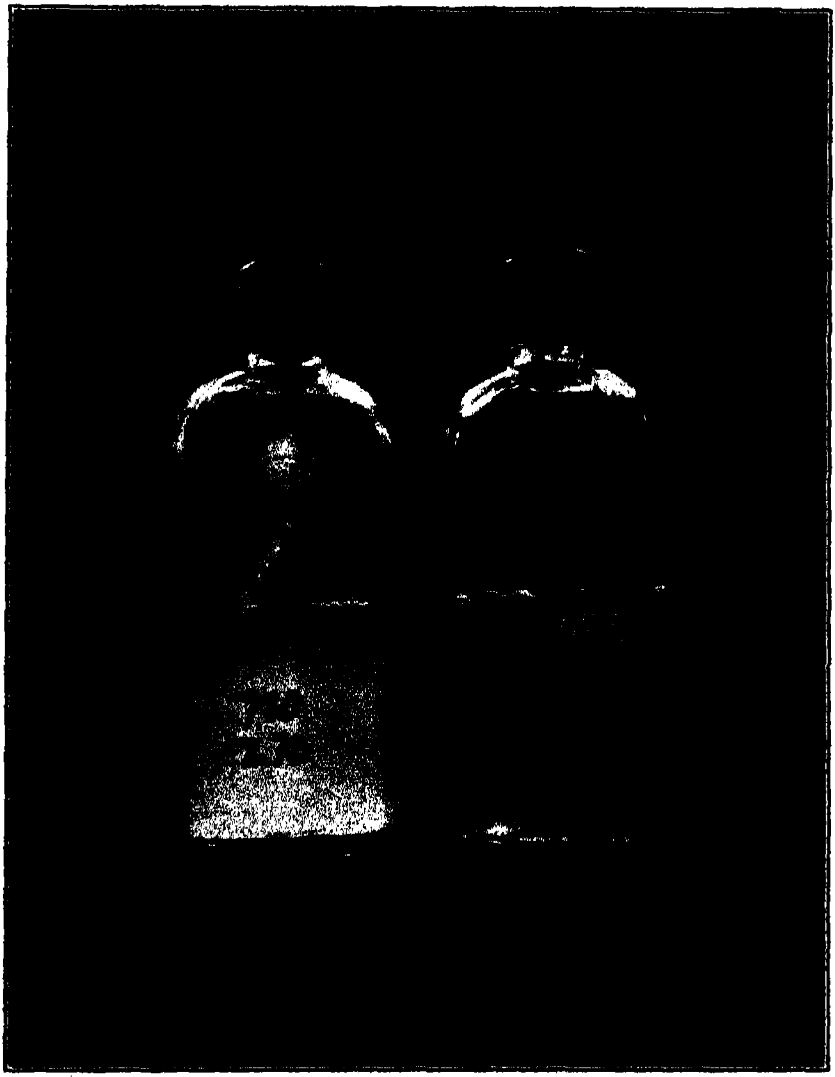


FIGURE 6

action is also produced (Fig. 8). There are some difficulties to be solved before a preparation of this kind suitable for clinical use can be made but it seems probable that a mixture which will produce a rapid anti-diabetic effect and also a prolonged one, will, in due course, be made available. Clinical trial of this mixture is now being made.

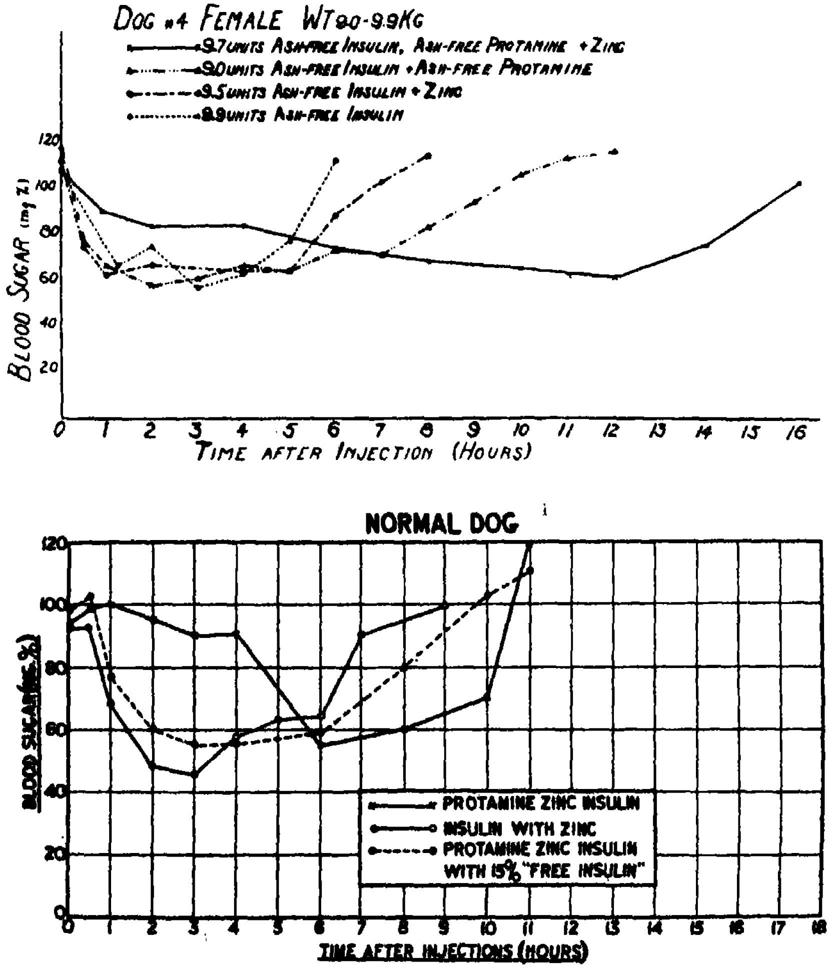


FIGURE 7 (upper); FIGURE 8 (lower), both from Kerr and Best.

PROTAMINE INSULIN IN DEPANCREATIZED DOGS

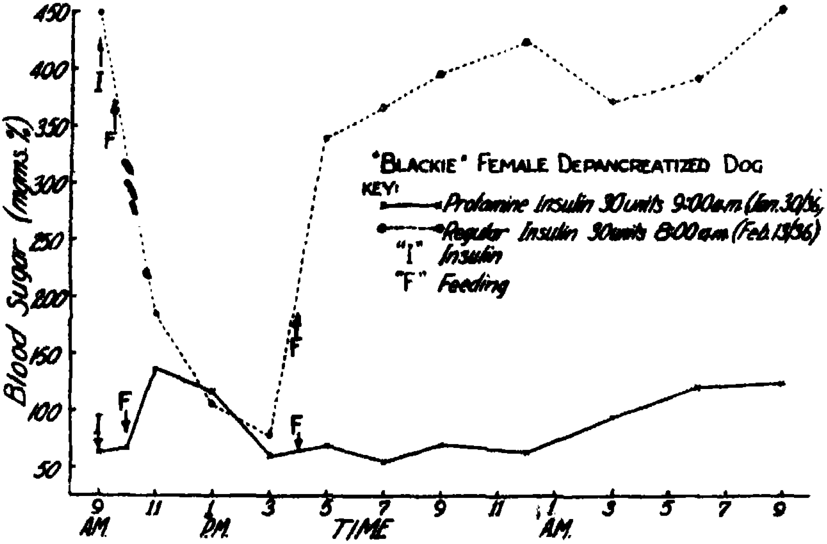
While the use of protamine insulin in diabetic patients had been investigated in some detail before these experiments on dogs were initiated considerable interest is attached to the findings in a completely depancreatized animal. Dr. Kerr has found it possible to keep several of the members of our colony of diabetic dogs in an excellent state of health and on a very liberal diet with one dose of protamine or protamine zinc insulin daily—20 units approximately for a 10 kilogram dog. The animals excrete only small amounts of sugar of the same order that are observed with two doses of regular insulin. When the daily dose of regular insulin (20 units) is given at one injection large amounts of sugar are excreted (Table 1, Kerr and Best). These results provide additional evidence that a large part of the insulin administered is excreted or otherwise lost when its absorption is very rapid. As in human patients the fluctuations of blood sugar throughout the day are largely eliminated and the incidence of hypoglycaemic reactions is very definitely less (Figs. 9 and 10). The results on diabetic dogs indicate that protamine insulin is a much more effective therapeutic agent than regular insulin.

TABLE I

Dog	Regular Insulin		Protamine Insulin	
	Dose of Insulin	Sugar Excretion (Daily average 7 days)	Dose of Insulin	Sugar Excretion (Daily average 7 days)
"M"	17 units (q. a. m.)	40.9 g.	17 units (q. a. m.)	1.0 g.
"R"	26 units (q. a. m.)	13.2 g.	26 units (q. a. m.)	1.7 g.
"P"	34 units (q. a. m.)	56.1 g.	34 units (q. a. m.)	5.6 g.
"B"	30 units (q. a. m.)	48.3 g.	30 units (q. a. m.)	2.7 g.

HYPOGLYCAEMIA AFTER INJECTIONS OF PROTAMINE INSULIN

Observations on diabetic dogs have shown, in confirmation of clinical findings, that while the incidence of hypoglycaemic reactions is less with protamine insulin than with regular insulin those produced by the protamine preparations are often much more severe. No difficulties are encountered when the hypoglycaemia is treated immediately and plenty of sugar is made available. It is apparent that the hypoglycaemia produced by protamine insulin is more insidious in onset and, perhaps for this



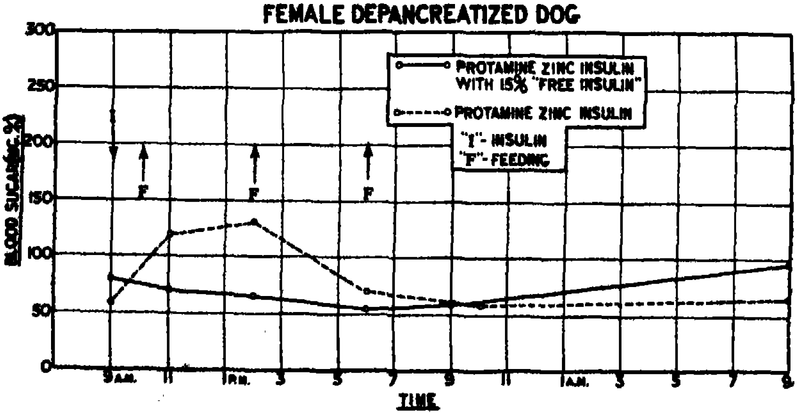


Figure 9 (upper); Figure 10 (lower), both from Kerr and Best.

reason, more difficult to correct than that produced by unmodified insulin. These findings emphasize the point that great care should be taken to prevent hypoglycaemia when protamine insulin or protamine zinc insulin is used.

DIET AND PROTAMINE INSULIN COMPOUND

Since the effect of one injection of protamine zinc insulin may persist for from 24 to 30 hours one dose per day may provide adequate insulin therapy in many clinical cases. This is the objective which most clinicians have in view. Since this preparation contains no appreciable amount of "free insulin" the rapid utilization of sugar very soon after administration, which is a characteristic effect of regular insulin, is not usually observed. Furthermore, the time after injection at which the lowest level of blood sugar is secured is much later than with unmodified insulin. For these reasons clinicians have found it necessary to make a redistribution of the food intake to provide larger amounts of carbohydrate later in the day. By this procedure a greater utilization of carbohydrate is secured and the incidence of the late hypoglycaemic reactions is decreased. The reader is referred to the clinical literature for details of the methods used.

SUMMARY

The results of Danish workers have made available a compound of insulin and protamine which exerts a prolonged anti-diabetic effect in cases of diabetes mellitus. Investigations initiated in the University of Toronto have shown that zinc may play an important rôle (1) in the stabilization of the protamine insulin compound and (2) in further prolonging the absorption of insulin. As a result of this series of studies a protamine zinc insulin preparation of satisfactory potency and stability, and contained in one vial, was made available for clinical trial. This product has been tested in many diabetic clinics and is now generally used. It is possible that this preparation may be further improved by the provision of a fixed amount of "free insulin" in the mixture. Some of the problems arising out of the use of these materials have been discussed.

Protamine insulin and protamine zinc insulin by enabling clinical and laboratory investigators to procure a more uniform and prolonged absorption of the anti-diabetic substance may assist materially in the investigation of many problems in carbohydrate metabolism.

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Recent Advances in Entomology

The revised second edition of "Recent Advances in Entomology," by A. D. Imms, gives promise of being as useful and as valuable a book for the next few years as the first edition has been since its appearance in 1931. The first edition was welcomed by all entomologists, particularly teachers, advanced graduate students and investigators.

The new edition is easy to read and summarizes in a very satisfactory manner the recent advances made in morphology, metamorphosis (including hormones), paleontology, sense organs and reflex behavior (visual stimuli in particular), coloration, ecology (including biological races and phase problems), and biological control. Some of the chapters have been revised considerably. The second edition has 56 new pages of text matter including some 27 new illustrations. The literature cited is presented in abbreviated form after the chapters discussing the topics named above.

The second edition should be found in all scientific libraries used by entomologists. It will also make a valuable addition to a personal library.

—Alvah Peterson.

Recent Advances in Entomology, 2nd edition, by A. D. Imms. 435 pages. Philadelphia, P. Blakiston's Son and Co., 1937. $5.00.

THE MALE SEX HORMONE

SOME FACTORS CONTROLLING ITS PRODUCTION AND SOME OF ITS EFFECTS ON THE REPRODUCTIVE ORGANS

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That the testis has a function other than the production of spermatozoa has been known for many years. Indeed, the first experimental demonstration of endocrine activity for any organ occurred in 1849 when Berthold transplanted testes in the male fowl and observed that the usual external effects of castration did not occur in the bird bearing a transplanted gonad. Berthold's work has been confirmed repeatedly and, indeed, the effect of testicular hormone on the comb is at this time the basis of the principle method employed in gauging the activity of male hormone preparations. Complete accounts of the effects of testicular hormone upon the plumage and head furnishings of birds are given by Moore (1932) and Domm, Gustavson and Juhn (1932). Moore (1932) Witschi (1932) and Willier (1932) have adequately considered the question for lower animal forms as well as the embryological relations.

Berthold's observations on the relation of the testis to secondary sex characters in the fowl were eventually applied to mammals and it is now known that the normal function of the sex-accessory organs, viz., the seminal vesicle, prostate, epididymis, and Cowper's glands, depend upon the internal secretion of the testis. Furthermore, there is excellent evidence for the existence of a testis-hormone control over physiological maturation of the spermatozoa. Morphologically, the sperm are, apparently at least, mature when they are released from the testis into the epididymis. However, such sperm have a low capacity for fertilization. After a period of time spent in the epididymis under the influence of the male hormone their fertility is enhanced. This period of residence in the epididymis is looked upon as one during which physiological maturation occurs.

We, therefore, recognize the profound influence exerted over a group of reproductive organs by the internal secretion of the testis. However the testis itself is under the immediate control of another endocrine organ, the anterior pituitary. This minute gland is believed to secrete two hormones which influence the activity of the male gonad. One of these is concerned with the stimulation of spermatogenesis and seems to be identical with the hormone that effects follicular growth in the ovary. The identity of the second hormone, which is involved in the stimulation of the interstitial cells and consequently with the production of male hormone, is less certain. Wallen-Lawrence, and Hisaw and his collaborators have presented evidence that would associate it with the pituitary hormone which stimulates luteinization in the ovary. More recently Evans, Simpson and Pencharz have suggested that a separate hormone, the interstitial cell-stimulating hormone, is the active factor. Regardless of which of these is the hormone actually involved in the stimulation of the interstitial cells it is possible to induce, selectively, either spermatogenesis or male hormone secretion in suitable test animals. The subject used in these studies is usually the hypophysectomized rat since the action of the hormone in question may be studied in the absence of any complications which might be introduced by the animal's own pituitary.

There are other influences which are important in normal testicular function. Such dietary factors as deficiencies in Vitamines A and E and in the mineral manganese have all been shown to result in sterility. The male hormone secretion of the testis is apparently not appreciably altered by these deficiencies since the sex-accessory organs have been reported by most workers to be normal. A somewhat different condition is observed in rats on a vitamine B-deficient or an inanition diet. Such animals have testes which show apparently normal spermatogenic activity, but which have a damaged endocrine function.

Thyroidectomy in young animals impairs both the spermatogenic and endocrine functions of the testis. The damage is much less severe in the adult animal. Hyperthyroidism, induced by the repeated administration of thyroid substance, results in a profound decrease in testis size. Microscopical examination of the sex organs of hyperthyroid animals reveals the loss of both the spermatogenic and endocrine functions of the testis. The exact mechanism involved in the testis damage induced by either hypo- or hyperthyroidism is not known, but it seems probable that the anterior pituitary is involved since profound histological changes are present in the hypophyses of such animals. In the case of hyperthyroidism the possibility that the increased metabolic rate is a deterrent to normal testicular function cannot be disregarded. Febrile conditions, generally, damage the testis. The factor involved here probably is the increased temperature to which the testis is subjected.

Related to the condition seen in the testes of animals in febrile states is the histological picture observed in the cryptorchid testis. Observations dating back to Sir Astley Cooper in 1830 and more recently emphasized by Crew and Moore have indicated that the scrotum, through its capacity for heat loss, exercises an important influence in mammalian spermatogenesis. The lower, by several degrees Centigrade, temperature of the scrotum is exceedingly important for normal spermatogenesis in mammals (whales, rhinoceroses, elephants, and cetaceans are exceptions). Thus failure of the testis to descend into the scrotum from the abdomen or its replacement, by surgical procedures, into the abdomen does not permit the production of sperm. If a testis which is producing sperm is confined by surgical procedures spermatogenesis is halted. The degenerative changes which occur are in the inverse order of spermatogenesis, i. e., the spermatozoa are lost first with the spermatids, spermatocytes, and spermatogonia following in that order. The spermatogonia are relatively very resistant and it is usually very difficult to be certain that a few are not present even after many months. Perhaps the only procedure that will give definite evidence concerning the survival of spermatogonia is the replacement of the testis in the scrotum. Surviving germ cells will permit the resumption of spermatogenic activity.

It is commonly supposed that only the germinal elements of the testis are impaired when the organ is subjected to the condition of cryptorchidy. Thus it is said, e. g., Moore (1932) that the endocrine function of the testis is quite normal. This observation is unquestionably true in instances where the cryptorchid condition has existed for a relatively short time. Most observations on the rat have continued for only a few months and as far as the writer knows none have been made in cases of more than six months. In the guinea pig, the other animal commonly used in these studies, one year has been the maximum. In man the reports on cryptorchid testes, naturally occurring cases, of course, are uniformly lacking in precise evidence regarding the condition of the accessories.

This question first aroused the interest of the writer during an investigation of the hormonic control exerted over the pituitary by the testis. It had been claimed by Mottram and Cramer (1923) and more recently by McCullagh (1932) that the germinal epithelium produces a hormone that has nothing to do with the stimulation of the sex-accessories, but which is concerned with the control of the hypophysis. This control, briefly, is essentially an inhibitory effect. Thus, removal of the gonad is followed by a condition of hyperactivity in the anterior pituitary. In animals whose testes are damaged by cryptorchidy, x-ray, or vitamin deficiency the hypophyses show much the same reaction as after castration. Inasmuch as the sex-accessories of such animals are normal it was reasoned that the testis-hormone which is concerned in the activation of the accessory organs does not affect the hypophysis. It followed, with this line of reasoning, that the testis produces a different hormone and, since the spermatogenic elements are damaged by the various treatments mentioned above, it seemed logical to suppose that this second hormone is produced in the seminiferous tubules. McCullagh's experiments led him to postulate that this hormone is a water-soluble substance, in contrast to the fat-soluble hormone which stimulates the sex-accessories. On the other hand, the writer had been able to show that the fat-soluble hormone does exert a controlling effect on the hypophysis (Nelson and Gallagher, 1935). It was observed, however, that the quantity of hormone required to achieve the end-point was considerably greater than the amount necessary for maintenance of the sex-accessories. These findings strongly urged the possibility that a single testis-hormone might be concerned in the control of hypophysis and sex-accessories, and suggested that perhaps a more exhaustive study of the cryptorchid animal, than had hitherto been made, should be undertaken.

Accordingly, a large group of young male rats were set aside for study. Eighty-seven of these were made cryptorchid and sixty-nine were castrated. All operations were made between the ages of 39 and 44 days. Fifty-eight males selected from the same litters as the above animals were set aside as untreated controls. Later an additional thirty-six males were made cryptorchid. No castrate or unoperated controls were included in this series.

At intervals of about 30 days representatives of three groups were sacrificed and the pituitaries, testes, seminal vesicles and prostates were removed, weighed and prepared for study. Thus animals were sacrificed at intervals from the thirtieth to the five hundred and tenth day after operation. The number of animals sacrificed at each stage varied somewhat, but in general there were three or four cryptorchid, three castrate, and three normal animals. The occasional death of experimental animals during the long period of time covered by the experiment added cases which did not fit into the regular intervals of the experiment. Table 1 shows the data collected on the sex-accessories of the cryptorchid animals together with a part of the data for the castrate and normal animals. It will be observed that the seminal vesicles of the cryptorchid animals continued to develop normally for about six months after operation. In the animals killed after seven months the size of the seminal vesicles was was slightly decreased, but the difference is not marked. However, after 240 days there was a marked decrease in the size of the seminal vesicles, and the beginning of histological evidence for a decreased male hormone effect. During the succeeding months this became progressively more apparent until the size of the seminal vesicles was only slightly larger than that of castrates and the histological pattern was not distinguishable from the castrate. The prostate gland retained a normal size and structure until about 400 days after operation. After 500 days the size of the prostate was markedly decreased, but still considerably above the castrate level. Histologically the gland showed evidence of a lowered male hormone effect.

The fact that the seminal vesicles show "castration effects," i. e., a lowered male hormone level, in advance of the prostate is not surprising since it has been shown that the seminal vesicles require from 2 to 3 times as much male hormone as the prostates to prevent or correct the changes induced by gonadectomy. Of further interest are the observations that were made on the hypophyses of the animals in the cryptorchid series. Changes which closely simulated those occurring in the pituitaries of castrate animals, but appearing later than in the castrate controls, were present. After 75 days the "castration changes" in the pituitaries were marked enough to definitely indicate a lowered output of hormone by the cryptorchid testis. It had been shown in earlier studies that the hypophysis required about twice as much male hormones as the seminal vesicle to prevent castration changes. Thus the three organs which were used to gauge the production of male hormone by the cryptorchid testis showed castration changes in the following order: pituitary, seminal vesicle, prostate. Furthermore, as has been noted, this order corresponds exactly with the relative requirements of these organs for male hormone. Since the hormone requirement of the pituitary is very high it is not surprising that it should be the first to show castration changes in an animal whose testis-hormone production is decreasing. It is to be expected that the seminal vesicle would show changes later than the pituitary, but in advance of the prostate whose hormone requirement is relatively low.

In addition to demonstrating for the first time that the cryptorchid testis does not maintain a normal output of male hormone this experiment seems to indicate that it is quite unnecessary to postulate the existence of a separate hormone, produced in the seminiferous tubules, which controls the anterior hypophysis. It seems reasonable to explain the hormonic control exerted by the testis over the several organs on the basis of a single hormone. In the light of our present knowledge this hormone probably is testosterone. In view of the many allied substances which qualitively resemble the activity of testosterone it would be unwise to assume that the mother substance, e. g., testosterone, circulates in the blood unchanged and provides the necessary effect upon the hypophysis and the sex-accessories. It is quite possible that the mother hormone undergoes some change before it acts upon any one or all of the end-organs. The major point to be emphasized here is the fact that the hormone active in the control of the pituitary as well as the sex-accessories is a sterol, not a water-soluble substance.

Although the testes of the long-time cryptorchid rat are not producing sufficient male hormone to maintain a normal pituitary or sex-accessories it is possible to stimulate them to do so. In a series of 25 males which had been cryptorchid for 360 to 450 days each animal was operated upon for the removal of one testis, one seminal vesicle and a piece of prostate. The condition of these tissues was the same as has been previously outlined. These animals were then injected daily with 50 rat units of Antuitrin-S (an extract of pregnancy urine containing gonad-stimulating hormone) for 10, 20, or 30 days. At the end of the experimental period the animals were sacrificed and the hypophyses, the remaining testis and seminal vesicle, and the prostate were removed for study. The results of this experiment were striking. In all animals the seminal vesicles and prostates removed after the period of treatment were histologically normal and were as large or larger than normal. In many instances the seminal vesicle removed after the period of treatment was ten times as heavy as the one removed for control purposes. The pituitaries also showed the effect of an increased output of testis-hormone. The castration changes, which in the 360–450 day cryptorchid animal are very marked, were completely corrected in the animals treated for 30 days. The testes obtained after the period of treatment were slightly heavier than the control testes. Histological study showed that this was due entirely to a slight increase in the size and number of interstitial cells. In view of the marked increase in male-hormone production it was surprising to find relatively little change in the interstitial cells.

The fact that the hormone production of the cryptorchid testis may be stimulated by gonadotropic hormone suggests that the hypophysis of the cryptorchid animal is basically at fault. This is surprising in view of the fact that it has been shown by a number of workers that hypophyses from cryptorchid animals contain more gonadotropic hormone than do hypophyses from normal males. These results were obtained with animals which had been cryptorchid for relatively short periods of time and may not apply for cases of longer duration. The results of the experiments recounted here suggest that such is probably the case and they urge the re-examination of the accepted idea that the presence of many enlarged and vacuolated basophiles is always indicative of increased gonadotropic activity of the hypophysis.

We have described the important relation between the hypophyseal gonadotropic hormones and the testis. There can be no doubt that normal testicular function is dependent, basically, upon the hypophysis. There is, however, an accumulating body of evidence which indicates that the testicular hormone itself plays some role in the production of sperm. The first suggestion of this relationship appeared in the report of Walsh, Cuyler and McCullagh (1934) that crude extracts of male hormone would not only maintain the sex-accessories of hypophysectomized males, but would also maintain the testes in an entirely normal condition. This amazing finding was finally confirmed by Nelson and Gallagher (1936) using extracts of male hormone prepared from human urine. It was shown, however, that only the spermatogenic elements of the testis were maintained in a normal condition. The atrophic changes which occur in the interstitial cells after hypophysectomy were not prevented. At first consideration it would appear that the physiological dictum, which states that the secretion of a gland has no stimulating effect on that gland, is distinctly violated by the results reported above. However, this is only an apparent violation if one remembers that the male-hormone is produced by the interstitial cells and that the latter have not been stimulated by the androgenic hormone, at least in the amounts thus far employed. Table 1 summarizes the pertinent data on these

TABLE I

CRYPTORCHID MALES

(Figures are Averages)

No. of Animals	Experimental Period	Body Weight (gms.)	Seminal Vesicles (gms.)	Ventral Prostate (gms.)
3	30	198	.529	.279
3	64	228	.765	.374
2	73	247	1.087	.428
3	84	243	1.005	.419
4	96	259	1.102	.436
3	120	278	1.040	.460
3	148	287	.943	.402
3	182	298	.968	.437
3	210	332	.877	.422
5	240	347	.354	.398
5	273	342	.153	.377
3	300	357	.125	.394
3	330	345	.097	.349
4	360	367	.119	.327
3	394	363	.086	.293
3	421	341	.091	.174
4	450	369	.075	.117
4	482	374	.052	.122
3	510	343	.057	.109
CASTRATE MALES				
3	30	175	.041	.052
4	96	238	.024	.042
3	240	303	.026	.037
3	300	328	.019	.033
3	510	323	.021	.035
NORMAL MALES				
3	30	217	.576	.268
2	96	295	.737	.345
3	240	378	.1216	.478
3	300	406	.1375	.462
3	510	427	1.284	.484

observations. It should be noted that injections of male hormone must be initiated within 12 days after hypophysectomy if spermatogenesis is to be maintained. In instances where animals were allowed to remain untreated for longer periods spermatogenesis ceased or if treatment was postponed for 3 or 4 weeks it was not possible to reinitiate spermatogenesis.

In addition to confirming the original observations of Walsh, Cuyler and McCullagh it has been possible to show that male hormone extracts will maintain normal spermatogenic activity in the testis of the hypophysectomized animal for as long as 60 days. These males have marked libido and in a number of instances have sired normal litters. This is of considerable importance since it definitely proves that the sperm which are produced after hypophysectomy are quite normal. Furthermore this observation sheds light upon the question of the control of libido in the male animal. Since libido is lost more rapidly after hypophysectomy than after castration it has been supposed that the male hormone has little to do with libido. The evidence related here renders that supposition open to question since male hormone, in the entire absence of the hypophysis, will restore libido. A more reasonable explanation for the rapid loss of libido after hypophysectomy would be based upon the more serious consequences attendant upon ablation of the pituitary.

Although the very nature of the procedure employed in preparing the extracts almost definitely eliminated the possibility that gonadotropic hormone had been present in the extracts, and consequently have been responsible for the maintenance of spermatogenesis, we made a study of the effect of the material on the immature rat ovary. Even in very large dosage no stimulating effect could be demonstrated.

The recent availability of the male hormone in crystalline form permitted a further check of the absence of a pituitary effect as contributing to the results observed with the urine concentrates. Furthermore, it was hoped that the use of crystalline androgenic substances in the hypophysectomized male would be of value in elucidating the nature of the action of the male hormone on the testis. The results with the urine concentrates had suggested that the explanation might be found in the fact that the scrotum of the hypophysectomized male injected with male hormone is maintained in a normal condition while the scrotum of the untreated control regresses. It seemed possible that this regression of the scrotum might be an important factor in the atrophy of the testes since the latter are apparently forced into the inguinal canal and finally into the abdomen. The higher temperature of the abdomen would possibly contribute to the cessation of spermatogenesis and might be the major factor responsible for it as it is in the case of cryptorchid testes. Since the testes of animals treated with male hormone are retained in scrota which appear normal it seemed reasonable to entertain the theory that scrotal maintenance might be responsible for the continuation of spermatogenesis in the absence of the pituitary. Although this idea appeared to be a satisfactory and simple explanation for the observations on animals treated with the urine concentrates the results with the crystalline androgens do not support it.

The crystalline androgens used in this study were testosterone, androsterone, dehydroandrosterone, androstanedione, androstenediol (trans), androstenediol (cis) and androstenedione. All of them were prepared synthetically.

Testosterone is the most potent androgenic substance that has been prepared. It was first obtained from testis tissue and is supposed to be the true testicular hormone.

Androsterone occurs in urine and probably was the active substance in the urine concentrates employed in the earlier studies. It is prepared from cholesterol and has about one-tenth the androgenic activity of testosterone. Androsterone is used as the international standard for the comparison of the androgenic activity of crystalline substances.

Dehydroandrosterone is also found in human urine. It has been synthesized and has about one-half the activity of androsterone.

Androstanedione has not been found to occur naturally, but has been synthesized from androsterone. It has slightly less androgenic activity than androsterone.

Androstenediol (trans) and androstenediol (cis) do not occur naturally but are synthesized from testosterone. The former has a lower androgenic potency than dehydroandrosterone while the latter Androstenedione does not occur naturally but is prepared from dehydroandrosterone. It has about the same activity as androsterone. For a complete discussion of these and other androgenic substances the reader is referred to the recent review by Koch (1937).

In the present study of the action of these substances the routine procedure adopted for their administration was the

TABLE II

HYPOPHYSECTOMIZED MALES TREATED WITH ANDROGENIC HORMONES

(Weights are given as averages)

No. of Rats	Body Weights		Hyp. Period Days	Treatment			Organ Weights (gms.)			Sperm Motility
	First	Last		Period Days	Hormone (daily dose)	Testes	Seminal (full)	Vesicles (empty)	Prostate	
Testosterone										
3	229	195	23-24	20-21	2 mg.	1.287	2.982	.877	.733	Exc.
4	275	232	23-24	20-21	1 mg.	1.243	1.815	.651	.472	Exc.
5	243	203	23-24	20-21	0.5 mg.	1.158	1.464	.519	.463	V. good
Androsterone										
3	272	230	23-24	20-21	2.5 mg.	2.214	1.609	.529	.483	Exc.
3	281	237	23-24	20-21	1.5 mg.	1.882	1.159	.436	.365	Exc.
3	238	197	23-24	20-21	1.0 mg.	1.785	.958	.363	.277	V. good
2	226	185	23	20	0.5 mg.	1.963	.498	.355	.220	V. good
Dehydroandrosterone										
3	245	210	23-24	20-21	3.0 mg.	2.120	1.145	.443	.454	Exc.
2	242	212	23-24	20-21	2.0 mg.	2.019	.859	.335	.359	Exc.
3	239	210	23	20	1.0 mg.	1.789	.627	.295	.276	Exc.
2	242	213	24	21	0.5 mg.	1.317	......	.163	.075	Good
Androstanedione										
5	276	219	23-24	20-21	1.5 mg.	2.379	1.529	.442	.517	Exc.
2	244	197	23-24	20-21	1.0 mg.	2.117	1.297	.375	.415	Exc.
3	248	207	23	20	0.5 mg.	2.141	.350	.206	.170	Exc.
2	237	208	23	20	0.25 mg.	1.221	.209	.175	.137	Good
1	290	247	23	20	0.125 mg.	.899	......	.139	.073	No Mot.
Androstenedione										
2	228	177	23	20	1.0 mg.	2.016	1.241	.460	.515	Exc.
Androstenediol (cis)										
2	239	196	23	20	1.0 mg.	1.790	.497	.312	.215	Exc.
Androstenediol (trans)										
2	225	185	23	20	1.0 mg.	.750	.142	.113	.084	No Mot.
Controls										
12	278	217	22-24	......	....	.527	......	.083	.054	No Sp.
Normals										
21	267	......	......	......	....	2.432	.963	.281	.295	Exc.

solution of the materials in peanut oil so that the desired daily amount was given in one-half cc. The animals used were adult male rats four or five months of age. Injections were begun on the second day after hypophysectomy and were continued for 20 days. Table 2 summarizes the pertinent data in these experiments.

It will be noted that although all of the synthetic materials with the exception of androstenediol (trans) were active in maintaining spermatogenesis, testosterone, which is the most potent of the androgenic substances is the poorest, with the exception of androstenediol (trans), in spermatogenic effect.

TABLE III

Comparison of Androgenic Substances on the Basis of the Various Tests

	Testes	Sex-Accessory Hypophysectomized Rat	Castrated Rat	Comb-Growth
Androstanedione	1	2	4	4
Androstenedione	2	3	2	3
Androstenediol (cis)	3	6	5	6
Dehydroandrosterone	4	5	6	5
Androsterone	5	4	3	2
Testosterone	6	1	1	1
Androstenediol (trans)	7	7	7	7

Androstanedione, a relatively weak androgen is the most active of the substances studied in maintaining the testis. This same lack of relationship between the potency in stimulating the sex-accessories and in maintaining spermatogenesis was shown by the other substances. Table 3 presents the rating for these compounds in terms of their capacity to maintain the testes in hypophysectomized rats and, for the sake of comparison, their potency values in the comb growth and sex-accessory tests. It is evident that the varying action of the different androgenic substances upon the testes cannot be ascribed to their potency in terms of male hormone activity. Nor is it possible to explain the different effects upon the basis of variations in the structural make-up of the substances. Androstanedione and androsterone are saturated substances while the others are unsaturated, i. e., they have a double bond in their structure. Most of the substances have a ketone and a hydroxyl group in their structural constitution although their positions may vary. There is no relation between position of these radicals and the potency of the compounds. Perhaps the most reasonable relationship between structural constitution and potency, insofar as maintenance of the testis is concerned, is found in the fact that the two most active substances, e. g., androstanedione and androstenedione have two ketone groups. However, dehydroandrosterone and androstenedial are very active substances and they have a ketone and a hydroxyl group, and two hydroxyl groups, respectively. This same lack of correspondence between structure and testis-maintaining potency has been observed in attempts to relate structure to androgenic, i. e., comb-growth or sex-accessory stimulation, potency.

It will be recalled that spermatogenesis could not be revived in rats hypophysectomized for several weeks with the urine concentrates. A similar failure was observed when the crystalline androgens were employed.

Attention is once more called to the tentative explanation, based upon the study of animals treated with urine concentrates, for the testis-maintaining effect of male hormone. This idea was, briefly, that the well-developed scrota of the treated animals was important in enabling the testes to remain in the scrotum and consequently in maintaining spermatogenesis. While the earlier evidence distinctly favored this interpretation the more recent observations on animals treated with the crystalline androgens have caused us to abandon the idea. These results have emphasized the fact that the scrotum is definitely stimulated by androgenic hormone. Others (Hamilton, 1936, and Cutuly, McCullagh and Cutuly, (1937) have also noted this and, indeed, have advanced the idea, noted above, to explain the effect of androgens on the testis. The scrotal stimulating effect of the androgens can be shown to be proportional to the androgenic activity of the substance under test. On this basis testosterone should be, and actually is, the most effective scrotal stimulating substance. Animals injected with it, even in doses as low as 0.25 mgm. daily have very large and pendant scrota, yet their testes are not only poorly maintained, but indeed, with the lower doses they are almost as atrophic as the testes of untreated hypophysectomized animals; yet the testes of the testosterone treated animals remain in the scrotum while those of the untreated animals are abdominal or in the inguinal canal. On the other hand low doses of dehydroandrosterone or androstanedione, e. g., 0.5 mgm. daily will maintain quite satisfactory spermatogenesis yet the sex-accessories were only slightly stimulated and the scrota, although fairly well maintained, were definitely smaller than the scrota of testosterone-injected animals whose testes were markedly atrophied.

The lack of relationship between the androgenic potency and the capacity to maintain spermatogenesis of the crystalline substances is further portrayed by the observation that extracts of the corpus luteum will maintain spermatogenesis in hypophysectomized animals. The hormone of the corpus luteum is progesterone, a substance which is closely allied structurally to the androgenic substances. It is known that unpurified extracts contain, in addition to progesterone, a substance, epi-allo-pregnane-ol-one, which has a relatively low androgenic activity. That this substance probably was responsible for most of the effect obtained with corpus luteum extracts is shown by the observation that crystalline progesterone had only a slight capacity to maintain spermatogenesis (2.5 mgm. of progesterone daily was about equivalent in its effect to 0.5 mgm. of testosterone). However, the point to be emphasized is that both progesterone and progestin extracts which contain epi-allo-pregnane-ol-one are effective in maintaining the testis, yet neither had more than a very slight effect on the sex-accessories or the scrota.

The various experiments cited above have convinced us that the influence of the male sex-hormone on the scrotum plays a relatively minor role in the continuation of spermatogenesis in hypophysectomized animals which have received treatment with androgenic or related substances. The explanation for the maintenance of spermatogenesis, therefore, remains somewhat obscure. It is quite possible, of course, that the simplest explanation possible is the true one, viz., that the spermatogenic elements are directly stimulated by the treatment. In the absence of a more likely theory this is tentatively accepted. The major difficulty attached to its acceptance is the fact that attempts to revive spermatogenesis with male sex hormone have failed. This may, of course, be accomplished with hypophyseal gonadotropic hormone.

Although no definite explanation for the phenomenon we have discussed can be offered at this time the experiments are being continued along several different lines of attack. It is hoped that some satisfactory answer to this very puzzling action of the male sex hormone upon the organ that produces it may be forthcoming from these studies.

SUMMARY

The material discussed in this paper may be summarized briefly. The normal function of the testis depends upon several factors. Among these are the hypophyseal gonadotropic hormones, normal function of the thyroid, and certain vitamines. The testis has two functions, viz., production of sperm and of at least one hormone. The endocrine activity of the testis is concerned with the stimulation of normal function in the sex-accessory structures and with the control of hypophyseal activity. As these effects may all be produced by a single hormone it is unnecessary to postulate the existence of a water-soluble hormone produced by the seminiferous tubules.

Spermatogenesis is seriously impaired by subjection of the testis to confinement in the abdomen. It has been commonly supposed that the endocrine function of the cryptorchid testis is normal. However, it was shown that, in the rat, the production of male hormone is reduced to a very low level if the reproductive organs of animals bearing cryptorchid testes for more than eight months are studied.

Although there can be little doubt that hormones produced by the anterior hypophysis are of primary importance for normal testicular function, evidence was presented which strongly urges an important relation of the testicular hormone to the spermatogenic function of the testis. Sperm production may continue for at least 60 days after hypophysectomy if the animals are treated with preparations of male sex hormone. Such males not only have functional seminiferous tubules, but will mate with normal females and have sired normal litters.

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Wit and Wisdom Mixed with Folly

Here is an irritating, exciting, amusing and instructive book. But it is a book to be read with critical faculties full awake. Here, for example, is how the author holds up a rival theory to gentle ridicule:

"Since their arms had already undergone a process of shrinkage, owing to the lack of boughs from which to suspend the body weight, the calcium deposition and growth were concentrated in the lower extremity. Hence the arms lagged and the legs grew enormously, involving the perplexed prehumans in a postural dilemma. They had their choice of progressing in a pyramidal, quadrupedal posture, with the nose barely off the ground and what ought to be the base of the trunk elevated toward the inhospitable skies, or of attempting to balance upon their hypertrophied hind legs and to wabble through life on an unstable and shifting base of support. Owing to certain difficulties with the law of gravity encountered in depressing the intaking end of the digestive tract below the outgoing, these creatures stood up, thereby exposing a vast area of vulnerable front to a hostile world. We need not accept this theory of the evolution of human posture through mineral deficiency, but the revelation of anatomical difficulties encountered cannot fail to evoke the sympathetic understanding of our anthropoid ape critics."

Now that strikes this reviewer as splendid scientific polemic. Literary skill is used to enliven a scientific argument. But Hooton uses his wit not only to make scientific theories interesting but to broadcast his prejudices in fields where he has no scientific competence. Like all wits, Hooton is a cynic but not even a cynic (if he is also a scientist) has the right to such flagrant dogmatisms as that "crime is increasing enormously." Sorting bones, even human skull bones, in the Peabody Museum does not qualify one to assert that the masses are incapable of ever understanding evolution. When he talks anatomical structure, Hooton's hereditarianism is moderate and aware of complexities; when he comes to the more intricate problem of the functions which relate to those structures, he becomes suddenly possessed of pontifical answers. The time surely has passed when any gifted amateur can dispose of the vexed problem of the relation of education to an intelligence, deemed wholly inherited, in a single deft paragraph.

Yet one can almost forgive him even this in return for his keen analysis of the race problem, his eloquent and sane eugenics, and for the many chuckles the book affords. But let the reader beware lest he find himself as this reviewer did, chuckling loudest when Hooton is wittily expressing one's own prejudices.

—H. B. English.

Apes, Men and Morons, by Ernest A. Hooton. x+307 pp. New York, G. P. Putnams, 1937. $3.00.

THE FEMALE SEX HORMONES

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I. THE OVARIAN CYCLE

In the short period of maturity preceding rupture the Graafian follicle increases rapidly in size, a process characterized by changes in the theca interna cells and by a loosening of the ovum in its enveloping granulosa. The ovum itself attains the stage of maturation. Since in most mammals this stage of follicular maturity occurs simultaneously with the pro-oestrous phase of the cycle, that is, the stage immediately prior to sexual receptivity, and since in most species the ripe follicle ruptures spontaneously with the ensuing oestrous phase, one may generalize to the extent of stating that oestrus and ovulation are essentially contemporary phenomena in animals displaying a well-defined oestrous cycle.

The ovum after its release is carried through the Fallopian tube and, in due course, arrives in the uterine cavity—the time required for this journey averaging about three days, according to Corner, "with singular unanimity regardless of species and the widely variant length of the tube." In the uterus, in the absence of impregnation, it rapidly degenerates. In the event of fertilization, which occurs in the tube or in the body cavity, the ovum, upon reaching the uterine cavity, becomes implanted in the prepared endometrial bed, the precise process of which varies according to species. Upon fertilization, we speak of the entire cycle of activity as the "reproductive cycle," in contrast to the term "sexual cycle," applied in the absence of pregnancy.

Following upon follicular rupture and extrusion of the ovum, the walls, composed in the intact stage of rows of granulosa cells, undergo a comparatively rapid change in structure; the granulosa cells, and in some species certainly, the theca interna as well, enlarge and become fat-laden, richly supplied with capillaries, forming ultimately a prominent compact body, the *corpus luteum*. In the event of impregnation, this grows large and persists functionally until nearly the end of gestation. In the absence of fertilization it persists for a variable period, according to species; in most forms at least long enough to allow the ovum, if fertilized, to become implanted.

The primary—and first known—function of the follicular apparatus is that of nourishing and discharging the ovum. A second function, the incretory one, was discovered much more recently, and is only now coming to be understood. The corpus luteum, so far as we know, is essentially incretory in function, its secretion being quite distinct from, and in certain respects perhaps antagonistic to, that of the Graafian follicle.

II. SEARCH FOR THE OVARIAN HORMONES

With the cyclic changes which occur in the ovary as a background, it now becomes necessary to anticipate somewhat, by listing the essential endocrine functions of the female gonad as these have been established. In general, these may be summarized as:

1. Control of onset of puberty; this includes development of primary and secondary sexual characters, and, to some degree perhaps, normal body growth.
2. Maintenance of the accessory organs of reproduction.
3. Preparation of accessory organs for mating. This includes as well the behaviour-pattern of the animal.
4. Preparation of the endometrium for implantation of the fertilized egg.
5. Maintenance of the endometrium for nourishment of the embryo.
6. Preparation of the genitalia for parturition.
7. Growth and preparation of the mammary glands for lactation (Lactation, it should be noted, is not *initiated* by gonadal hormones; this specific and climactic duty is relegated to a pituitary factor).

With this list, then, of established functions, let us consider briefly the history of the arduous researches which placed these observations upon a firm experimental basis.

Our knowledge of female reproductive physiology began with the demonstration of Knauer (1896) that transplantation of ovaries in the experimental animal prevented the uterine atrophy which characteristically follows upon oophorectomy. His observation soon was confirmed and extended, particularly by Halban (1900) who, showed, in addition, that subcutaneous ovarian transplantation in the immature castrate female guinea pig resulted in attainment of normal puberty. In short, the ovarian functions include not only *maintenance* of the genital tract but its physiological *development* as well. Halban's observations have been confirmed and amplified in numerous laboratories since that time.

On the basis of these discoveries, an internal secretion was postulated. Conceived of as a single substance, considerable speculation arose as to its source. Early attempts at testing the secretion by the injection of ovarian extracts were largely unsuccessful or, at best, unconvincing and, although this method of approach was instituted in 1900 it was not until 1912 that Adler was able to produce indications of sexual activity in spayed animals with administration of aqueous extracts.

Numerous experiments were carried out in ensuing years, but final identification of an ovarian hormone awaited the striking experiments of Allen and Doisy (1922 *et seq.*). Their work of qualitative and quantitative assay was tremendously facilitated by a test reaction which had been unavailable to earlier investigators, namely that afforded by the vaginal smear technique, by means of which the vaginal rhythm, discovered in 1917 by Stockard and Papanicolaou, could be followed. Prior to 1917, the effects of test material injections could be ascertained only by the costly and time-consuming process of sacrificing the experimental animals. Stockard and Papanicolaou, however, found that the cellular changes in the vaginal lumen, as detected by examination of vaginal lavage contents, were rhythmic in nature, the rhythm corresponding precisely to phases in the ovarian cycle. Since such changes disappeared upon castration, their reappearance upon the injection of suitable extracts could mean only that an active principle was being employed and, moreover, that its effect could be *measured*. Using fluid aspirated from sow's ovaries, Allen and Doisy soon were able to arrive as a quantitative assay, and developed the Rat Unit of the ovarian follicular hormone. The value of their work, and the stimulus it provided to research in reproductive physiology, was incalculable. An adequate method for assaying was provided, which included at the same time a method for estimating potency. This accurate and simple means of bio-assay resulted in many new and fundamental discoveries.

Then, Frank, with his collaborators, in 1925 demonstrated the same active principle in circulating and menstrual blood in the human being. Moreover, it was shown to be cyclic in quantity, the average intermenstrual peak running about one Mouse Unit per forty cubic centimeters of blood. Larger amounts were found in the blood of pregnant women. The principle, indeed, came to be regarded as *the* "female sex hormone." Detailed chemical work was hampered severely, however, for several years by paucity of raw material. This impasse was dissipated three years later by Zondek. In connection with his epochal work on the gonadal relations of the anterior pituitary Zondek reported that urine of pregnancy contains tremendous amounts of ovarian oestrogenic hormone. This discovery proved extremely timely, in that it provided an abundant and cheap source of material, in aqueous medium and adaptable to chemical manipulation. In consequence, from 1928 onward progress has been amazingly rapid.

Chemists were quick to appreciate the practical importance of Zondek's findings, and chemical purification proved only a matter of time; only a year later Allen and Doisy and, independently, Butenandt, reported crystallization of the oestrogenic hormone, the product of which was named "theelin" by the former investigators.

Now, the discoveries of the 1920's led many to believe in a single ovarian hormone. Here was a substance which fulfilled a great many of the functions detailed above, and it seemed probable that upon proper testing it would satisfy as well the remainder of the rigid functional requirements. Doubts still persisted in some quarters, however, and this necessitates going back again some thirty-seven years to the turn of the century.

Reference has been made already to the corpus luteum. Now, this structure is present typically during pregnancy; its invariable association with the latter condition, indeed, led to many early speculations as to its possible functional significance.

Its coincidence with gestation had been noted, for example, by John Beard, in 1897, who, on purely theoretical grounds, postulated it to be essentially an "organ of pregnancy—that it served a necessary function during the course of gestation, probably in the maintenance of conditions essential to pregnancy. His reasoning was strictly of the arm-chair variety, but it is striking to reflect how closely he hit upon the truth. The German investigator, Born, (1900) speculated also, and in somewhat more detailed manner remarked upon the fact that in placental mammals, and in them only, a fully developed corpus luteum is always present and that it acquires its peak of development just when the embryo is attached to the uterus and the placenta is beginning to form. He observed also the decidual reaction on the part of the uterine mucosa, and suggested that these changes were the result of an internal secretion of the corpus luteum—and *not* the result of stimulus provided by the ovum-mechanism as was popularly supposed at that time. In short, the corpus luteum, by virtue of an internal secretion, prepared the mucosa for reception and implantation of the fertilized egg. Born died in the midst of his speculations, and the burden of experimental proof fell to his student Fraenkel (1903).

Reasoning that if Born were correct in assuming that implantation and placentation depend upon the corpus luteum, Fraenkel came to the conclusion that, *ipso facto*, early removal of the ovaries should prevent these phenomena from occurring. Accordingly, he extirpated the ovaries or destroyed the corpora lutea in recently mated rabbits. He was able to prove the hypothesis; implantation of embryos was prevented and pregnancy met an untimely interruption.

Leo Loeb (1907) furnished additional proof, now classical, of the incretory function of the corpus luteum. Loeb showed that the endometrium of the guinea pig, sensitized by the corpus luteum hormone, develops the decidual, or maternal, growth reaction as the result of the irritating effect of the early embryo *in utero*. For example, glass beads were inserted in the uterus following upon sterile copulation, upon the day when implantation normally should have occurred. A tumour of decidual cells developed in response. Loeb's work constituted the first experimental proof that the secretion of the corpus luteum prepares the endometrium for decidual response. This work has been amply confirmed and constituted for a long time the classical test for corpus luteum extracts. On the basis of Fraenkel's and of Loeb's observations, indeed, it was long believed by many that the corpus luteum supplied *the* ovarian hormone, and that none other was concerned.

The foregoing observations led two French investigators, Bouin and Ancel in 1910 to study the uterine changes in the rabbit, prepared in such manner as to possess functional corpora lutea in the absence of pregnancy. They utilized the fact that rabbits ovulate only upon mating, and for mating employed sterile (vasectomized) males, with the result that ovulation and corpus luteum formation was obtained without the supervention of pregnancy. Under this circumstance the corpora lutea develop just as though pregnancy had ensued, and persist for an appreciable time (some two weeks in the rabbit) during which the uterus undergoes changes typical of those occurring during gestation—in brief, a condition of *pseudo-pregnancy*. It was noted that the endometrium, the lining membrane of the uterus, underwent a characteristic proliferation, quite similar in detail to that typical of early pregnancy, and not unlike that displayed by the human endometrium late in the menstrual cycle. These proliferative changes attained a maximum in about eight days, after which retrogression set in, and the stage of rest was resumed in slightly more than three weeks. These changes never occurred in the absence of ovulation and corpus luteum formation.

The situation rested at this point until 1929, at a time when the so-called follicular hormone was attracting almost exclusive attention, when Corner, with a background of years of histological and experimental work on the physiology of reproduction, re-investigated the problem of the corpus luteum and settled the question of a possible internal secretion once and for all in a thorough-going series of experiments. To summarize these briefly, his observations may conveniently be condensed into three statements:

Ovaries were removed from rabbits 14–20 hours *post coitum*, at a time when the ova had been in the tubes 4–10 hours. In all cases there was complete failure on the part of the uterine mucosa to produce progestational changes such as those to be seen in intact females following upon mating. Embryos failed to survive. This observation confirmed Fraenkel and Ancel and Bouin.

Females were mated and, 18 hours later, were spayed, at which time small portions of the uterus were removed for examination. Injections then were given of a corpus luteum extract (obtained from the ovaries of pregnant sows). Upon the 6th day the animals were sacrificed, the embryos and uterus removed and examined histologically. In all respects both presented the same appearance as similar preparations from the intact 6-day pregnant animal.

Controls, carried out precisely as the foregoing, were given follicular hormone in place of the corpus luteum extract. As in the initial observations, none of the embryos lived, and the mucosa revealed no progestational changes.

As this very sketchy resumé shows, then, Corner's excellent work placed the proof of incretory function of the corpus luteum upon a firmly established basis. The active principle was named "progestin," and the observations made in the

Rochester laboratory soon were amply confirmed elsewhere. Corner and his student, Willard Allen, studied the various properties of their extract and continued its purification, a procedure which culminated in 1933 in the announcement of a crystalline product possessing all the known properties of the active principle. This was confirmed almost immediately in a number of laboratories (e. g. Fels and Slotta). Its structure was quickly established (Wintersteiner and Allen; Slotta *et alii*), and it was assigned the empirical formula $C_{21}H_{30}O_2$.

III. CHEMISTRY OF THE FEMALE SEX HORMONES

With the experimental proof established, and the purification achieved, let us next consider the progress attained in studies of the chemistry of these principles.

At the time the oestrogenic hormone was isolated and crystallized, Doisy gave it the empirical formula $C_{18}H_{22}O_2$ (theelin). Difficulty was anticipated, however, in clearing up its structural formula, and one would have been optimistic indeed at the time to have predicted that in the space of a few years this would be completely solved. We have here an instance, however, of how progress in a field apparently quite remote helped provide an extremely valuable key to the solution of the chemistry of gonadal principles. Fundamental researches by Windaus and Wieland culminated in 1928 by their demonstration of a close structural relationship between the bile acids and the sterols, in the course of which—and relevant to the subject at hand—they unravelled the chemistry of cholesterol. Capitalizing upon this work, Butenandt, in 1933, was able to show that structurally the sex hormones are related to this same group—a fact which had been suspected for some time. Moreover, pregnandiol $C_{21}H_{36}O_2$, a physiologically inert substance from pregnancy urine (Marrian, 1929; Butenandt 1929), separable from theelin and theelol, was converted by Butenandt into ***progesterone***, the purified progestin. It is not inconceivable, furthermore, that pregnandiol, in turn might be formed in the body from cholesterol, and might be regarded as an intermediate stage in the formation of gonadal hormones from cholesterol (or bile acids). It should be noted incidentally that Ruzicka has reported conversion of cholesterol into male sex hormone.

Three oestrogenic principles have been obtained from female tissues: oestrone—$C_{18}H_{22}O_2$, oestriol—$C_{18}H_{24}O_3$, and oestradiol—$C_{18}H_{24}O_2$, the last a dihydroxy derivative of oestrone, or dihydro-oestrone. In addition, the corpus luteum hormone, progesterone—$C_{21}H_{30}O_2$ has been isolated. Several additional oestrogenic principles have been reported, some, for example, from the urine of mares: equilin—$C_{18}H_{20}O_2$, and equilenin—$C_{18}H_{18}O_2$ (Girard, 1933).

All the sex principles possess a cyclopen taphenanthrene four-ring structure (Marrian and Haslewood, 1932) and are strikingly similar as to degree of oxidation and unsaturation.

Oestrone (theelin of Doisy) is an unsaturated hydroxyketone. Oestriol (theelol) is a trihydroxy compound, discovered by Marrian shortly after Allen and Doisy's announcement of theelin. Both these products are recoverable from urine. Butenandt and Hildebrandt demonstrated that oestriol can be converted into oestrone by dehydration *in vacuo* with potassium bisulfate.

Schwenk and Hildebrandt then reported an extremely important finding in the discovery of a dihydro derivative of oestrone —oestradiol, obtained through reduction of the ketone group to a secondary alcohol, the point of interest being that this compound is six times more potent than the oestrone from which it is derived. More striking still, this substance was soon isolated from liquor folliculi, the follicular fluid of the normal ovary by MacCorquodale *et alii* in Doisy's laboratory. There is reason to believe that it represents the pure female sex hormone, or "mother hormone," of which oestrone and oestriol are oxidation products.

Collip, in 1930 discovered an additional oestrogenic compound, recovered from urine of pregnancy. It was soon obtained in crystalline form and, regarded by Collip as a placental hormone, was given the name "emmenin," an ester of oestriol. It is of interest further to note that Andrew and Fenger have recently reported isolation of a crystalline nitrogenous compound from ovarian tissue, which is unique in that it apparently produces a delayed but prolonged oestrus in test animals, and, moreover, in that it appears to be much more powerful that oestrone. More work is needed, however, to establish clearly its separate identity.

Collip's emmenin is effective when administered orally, whereas other sex hormones are efficacious only upon injection—unless tremendous quantities are administered. Fed to immature female rats, it readily induces a condition of oestrus, without evoking any ovarian changes. It is practically ineffective in adult rats, normal or castrate, differing sharply from the other oestrogenic compounds in this respect. Marrian and his co-workers have established emmenin as oestriol glycuronate moreover it was demonstrated that during pregnancy practically all—99%—of oestrogenic material is excreted in this form or in similar combination. Physiologically much less active than oestrone, the opinion has been advanced that the formation of oestriol, followed by the formation of its glycuronate, constitute a protective mechanism against an over-activity of oestrone and oestradiol during the course of gestation.

Finally, progesterone, an unsaturated diketone, isolated in crystalline form, as mentioned, by Allen and Corner, Fels and Slotta. Its chemical nature was established beyond further doubt by the conversion of pregnandiol (*vide supra*) and of stigmasterol, a plant sterol—specifically the wax from soy beans—into the active substance.

Is there any significance to the fact that the sex hormones appear closely related to the sterols? This seems highly probable, when we consider that the latter group of compounds are regarded as vitally important constituents of living matter. The apparent relationship is highly suggestive, although our knowledge here begin to transgress the borderline of speculation, and further work is necessary. The probable significance has been suggested by Riddle, however, in the statement that "The artificial preparation of these sex hormones from sterols suggests that *in vivo* they are intermediary metabolites or derivatives of sterols. Certain differentiated cells in the ovary (and testis as well) perhaps also placenta, apparently have the power to make these conversions. In the female, oestrone and oestriol appear to be oxidation products of the hormone actually produced by the ovary."

IV. GONADOMIMETIC ACTIVITY OF THE PLACENTA

The placenta is primarily a structure developed during pregnancy for the nourishment and respiratory exchange of the embryo. In recent years, in addition to this long-known function, sporadic evidence has appeared which has been interpreted by some investigators to indicate an actual mechanism of internal secretion. It becomes difficult, indeed, to explain certain observations on any other basis. Certainly, at least, the placenta is definitely concerned in hormonal interrelations. Without going into detail, it should be noted that Halban

(1905) pointed out that, from a clinical standpoint, the placenta must serve an endocrine function. It has since been reported that in the human being the production of ovarian hormones continues unabated following oophorectomy—the source in this circumstance having been ascribed to placental tissue (Waldstein, 1929; Probstner, 1931). Moreover, Allen and Doisy, in their search for the distribution of oestrin, found especially large quantities in the human placenta—the amount increasing progressively with the course of pregnancy. Collip, as mentioned above, has isolated a substance, emmenin, from pregnancy urine which he regards as placental in origin.

Evidence with respect to progestin elaboration by placental tissue still is uncertain. Adler, de Fremery and Tausk (1934) reported finding detectable quantities of progestin in the human placenta at term—although whether this means that it is elaborated there, or merely is retained has not been ascertained. Selye, Collip and Thomson (1935) are of the opinion that secretion of progestin occurs, since the rat uterus will show well-defined progestational changes, and the mammary glands will be maintained in a well developed condition for periods up to six days following upon ablation of the ovaries and embryos. We have obtained evidence, moreover, indicative of the role played by the placenta in maintaining hormonal balance during gestation—evidence which may be interpreted in support of the progestin-secreting concept.

It is well known, for example, that removal of the ovaries during pregnancy, at least in the more common laboratory animals, will bring gestation to an abrupt end (e. g., dog, rabbit, mouse, rat, opossum). The rule is not an invariable one, however, since it was reported some time ago that the guinea pig will frequently carry to term in the absence of ovarian tissue (Herrick; Nelson). Oophorectomy in the mare, moreover, appears to exercise no adverse effect upon the course of gestation (Cole) and, finally, the human being furnishes probably the most striking exception of all, since ablation of the gonads even in very early pregnancy may exercise no deleterious influence (Pratt; Waldstein *et al*).

In these exceptions, however, either the pregnancies are in species characteristically monotocous, i. e., in which only one fetus is carried, or the litter size is frequently limited. In the guinea pig, as an example of the latter class, the number of young ranges from one to four, and scrutiny of data reveals that successful pregnancies after oophorectomy have been confined to animals carrying litters of not more than two. It would seem, *a priori*, that litter size may have some relation to the relative dependence upon ovarian support throughout pregnancy. When put to experimental test in the rat, this concept is borne out.

Rats commonly carry litters ranging from five to ten and twelve in number. If, however, the number of young is reduced by surgical intervention to a single fetus, removal of the ovaries shortly after midpregnancy does not interrupt the course of gestation, *provided* the additional placentae, i. e., those of the removed fetuses, have been allowed to remain *in situ* (Table 1). As noted in the table, in ten experimental animals, in every case the remaining fetus was carried to term, and was recovered alive after being allowed to remain *in utero* for one to two days past the expected time of parturition. Spontaneous delivery does not occur—the birth mechanism, in the rat at least, appears to be seriously impaired.

TABLE I

EFFECT OF PLACENTAL RETENTION FOLLOWING LITTER-SIZE REDUCTION AND OOPHORECTOMY

RAT	Laporotomy*	Oophorectomy	Result
1	13†	15	23; live fetus, 5.5 gm.; 4 extra placentae.
2	14	16	23; live fetus, 5.1 gm.; 3 extra placentae.
3	13	15	22; live fetus, 4.7 gm.; 3 extra placentae.
4	12	14	24; live fetus, 5.0 gm.; not viable; 2 extra placentae.
5	13	15	23; live fetus, 4.9 gm.; 4 extra placentae.
6	13	15	23; live fetus, 5.1 gm.; not viable; 3 placentae.
7	13	15	22; live fetus, 5.0 gm.; 3 extra placentae.
8	12	14	23; live fetus, not viable; 5 extra placentae, 3 of which were detached.
9	13	16	23; fetus, 4.8 gm. alive, but died shortly after removal; 3 extra placentae.
10	13	15	23; live fetus, 4.8 gm.; 4 extra placentae, 1 detached.

*Involving removal of one ovary and fetuses in excess of one.

†The figure in each column in this and in following tables represents the day of pregnancy when operation or sacrifice was carried out.

The necessity for the presence of adequate placental tissue for the continuance of gestation under these circumstances is revealed by examination of Table 2, a summary of cases, operated as in the first series, in which, however, the extra placentae were included in removal. In no case was pregnancy continued to term. Retention of one ovary under identical conditions, however (Table 3), sufficed to maintain a successful pregnancy.

TABLE II

EFFECT OF REMOVAL OF FETUSES AND PLACENTAE, WITH OOPHORECTOMY

Rat	Laparotomy	Oophorectomy	Result
15	12	15	20; placenta *in situ*, large. No fetus.
16	12	14	20; uterus empty and involuted.
17	12	15	21; uterus empty and involuted.
18	13	15	21; uterus empty and involuted.
19	12	15	21; uterus empty and involuted.
20	14	16	20; term-sized placenta *in situ;* no fetus.
21	13	15	20; uterus empty and involuting.
22	12	15	21; uterus empty and involuted.
23	13	15	22; uterus empty and involuted.
24	12	16	Allowed to run to 24th day. No evidence of delivery. Atrophic uterus upon post-mortem.
25	13	15	22; one small placenta, unattached.

It would appear therefore that presence of the ovaries is not necessarily essential during the entire course of gestation, even in the polytocous rat, provided too many young are not being carried and provided further that adequate viable placental tissue is present. The question of paramount importance is that of how the placental tissue functions in maintaining pregnancy. We do not know the answer to that as yet, since there is no evidence available that the rat placenta actually secretes pro-

TABLE III

EFFECT OF RETENTION OF ONE OVARY FOLLOWING REMOVAL OF EXCESS FETUSES AND PLACENTAE

Rat	Laparotomy	Result
31	12	Delivered one fetus 22nd day; perfectly normal.
32	12	Delivered one fetus 21st day; killed by mother.
33	13	Delivered one fetus 22nd day; fetus died following day.
34	14	Delivered one fetus 22nd day; perfectly normal.
35	15	Delivered one fetus 21st day; perfectly normal.
36	14	Delivered one dead fetus 21st day.
37	14	No delivery. Empty uterus at 23rd day autopsy.
38	14	Delivered one fetus 22nd day; perfectly normal.
41	13	Delivered one fetus 22nd day; perfectly normal.
42	15	Delivered one fetus 22nd day; killed by mother.

gestin. The working hypothesis has been advanced that a progestin-secreting mechanism most satisfactorily explains the observations noted, but this is as yet only a hypothesis. In all events it is quite evident that the placenta serves as an adjunct to the ovaries as an endocrine mechanism—or is concerned in maintaining a proper endocrine balance. Its capacity in this respect is in all probability better developed in some species than in others—in the mare or the human being, for example, in which the corpus luteum regresses or becomes non-functional at a relatively early age and in which, presumably, the placenta can assume the functional attributes of ovarian tissue in regulating endocrine balance.

The concept of the placenta as an auxiliary gland, capable of secreting progestin, or a progestin-like principle, during pregnancy would serve to explain the curious fact that oophorectomy in some forms need not terminate pregnancy, and at the same time would not be at variance with our concept concerning the importance of the luteal hormone during pregnancy. Further work is indicated, however, before we can speak with certainty.

In conclusion, an attempt has been made in this very brief sketch to indicate the major functions of the female sex hormones. A brief survey of their discovery has been sketched, including the highlights of the final triumph of their purification, chemical elucidation and synthesis. Evidence pointing to the placenta as a possible auxiliary organ of internal secretion has been touched upon, and, although conclusive evidence awaits further experimentation, the role of the placenta in maintaining hormonal balance is such as to justify, in the writer's opinion, use of the term "gonadomimetic" with reference to its endocrine activities.

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Radiant Energy

During the first thirty-five years following its birth, any branch of physical science can be expected to pass through a period of active development in which a confusion of ideas and notation comes into existence. So it has been with the measurement of radiation. This division of physical science was, for all practical purposes, born with the announcement of the Planck Radiation Law in 1900. Since that time, many methods of measuring radiation have been developed, not the least of which are the uses of the photographic emulsion and photoelectric cell. Until now, however, there has appeared no good critical survey of the field of radiation measurement. There has been much confusion and misunderstanding sometimes of simple ideas. The present volume removes this confusion and makes clear the problems to be encountered by one who would measure radiation. Under the meticulously careful editorship (and partial authorship) of W. E. Forsythe, this book, in the opinion of the reviewer is the best of the multiauthored scientific books which have recently appeared. Its discussions are short, direct and authoritative, yet there is no loss in coherence from article to article, so carefully has the material been edited.

This book should be of great assistance to all who have occasion to measure the strength of radiant energy during the course of their work.—C. E. Hesthal.

Measurement of Radiant Energy, edited by W. E. Forsythe. xiv+452 pp. New York, the McGraw-Hill Book Co., 1937. $5.00.

Dendrology

With the new interest in forestry and soil conservation the teaching of Dendrology must be decidedly increased in our colleges and universities if properly trained men are to be available to carry on the enlarged program. Suitable textbooks are a primary necessity in this program. The present textbook includes all the important forest trees of the United States and Canada and will, no doubt, take an important place, both in the classroom and in general reading courses. It is beautifully printed and illustrated. There is a general introduction with illustrations and definitions of flower, inflorescence, fruit, leaf, and twig characters, and in the body of the text very complete general descriptions and notes, distinguishing characters, botanical features, and range of each species.
—John H. Schaffner.

Textbook of Dendrology, Covering the Important Forest Trees of the United States and Canada, by William M. Harlow and Ellwood S. Harrar. 527 pp. New York, McGraw-Hill Book Company, 1937. $4.50.

THE THYROID HORMONE

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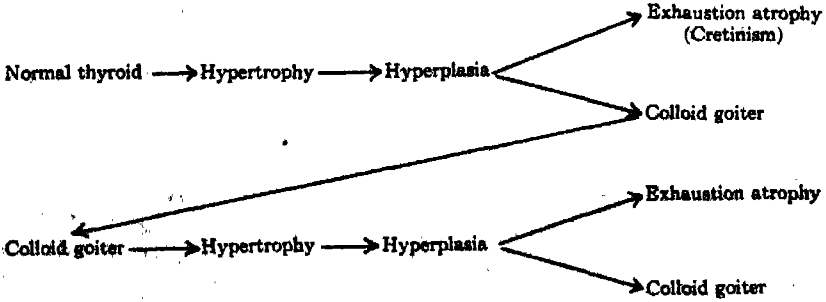
In this lecture I shall attempt to review briefly the principal facts of thyroid chemistry and physiology and some of its interrelations with other glands of internal secretion.

ANATOMY

Brief mention of the main anatomical changes will be helpful in correlating the chemical and physiological discussions which follow. *Ancestrally*, the thyroid is limited to the Chordates. In the lowest forms—tunicates, amphioxus and ammocoetes—it is represented by the endostyle organ, an elaborate midline pharyngeal epithelial groove. The connection between the endostyle organ and the ductless thyroid of all higher Chordates is established by the fortunate preservation of a single species—the lamprey—which in its larval state has an endostyle organ and in its adult form, the characteristic ductless thyroid follicles. This follicle is the thyroid unit and exists in essentially the same form in all vetebrates from the lamprey to man. It, therefore, seems safe to assume that it has essentially the same function throughout the vertebrates.

The thyroid unit is a closed rounded cyst-like vesicle of variable size (in man .05 to 0.5 mm.), lined with a single layer of low cuboidal epithelium. These epithelial cells are of two types, as first recognized by Langendorff—(1) chief cells and (2) colloid cells—and the necessary intermediate stages. These two types of cell occur in varying proportions but the chief cells in the normal gland always predominate. Because of the varying proportions of these two types of cell it is believed that they represent different stages in the secretory activity of a single cell type. The chief cell is the actively secreting cell and the colloid cell is the collapsed, spent cell. Filling the follicular spaces normally is a homogeneous amber colored globulin—the so-called colloid which gives to the thyroid its most characteristic anatomical feature. This colloid varies in density in different glands and in different follicles of the same gland and can be increased or decreased under experimentally controlled conditions which indicate that the colloid is a storage product. The blood supply of the follicle is composed of a rich network of wide, short capillaries, very similar to that of the lung alveolus. The blood supply to the gland, as a whole, is subject to extreme variations, but even normally it ranks with the 5 or 6 most vascular organs. The thyroid is richly supplied with nerve fibers which end both in the vessel walls and around some of the gland cells. Vasomotor fibers are present in great abundance but the presence of so-called secretory or regulatory nerves is still in doubt. The fact that nerve fibers terminate in end brushes about the gland cells is evidence that they have some function, but it has been clearly demonstrated that nerve fibers are not necessary for gland function, since autotransplanted thyroid in widely separated parts of the body undergoes hyperplasia and involution simultaneously with the non-transplanted tissue and can store and excrete iodine. These manifestations of function of transplants—long known to be due to some factor reaching the cells by way of the blood stream—have in recent years been proven to be due to the thyrotropic factor of the anterior pituitary. The thyroid gland is one of the most labile tissues in the body, capable of exhibiting morphological changes within a few hours. Because of this wide range of anatomical changes we are provided with a very delicate anatomical measure of functional variations. Unfortunately attempts to interpret these changes in relation to disease have caused as much confusion as clarification. This range of morphological changes may be designated as the anatomical cycle and represented schematically as follows:



The actively hypertrophic and hyperplastic stage always indicates stimulation of the gland cells, and so far as known, this is brought about solely by the thyrotropic hormone of the anterior pituitary. The colloid stage represents the return of the hyperplastic stage to its normal or quiescent condition, and the atrophic stage the permanently exhausted thyroid. There is no basis for assuming that the series of changes observed in the thyroid in association with simple goiter, with exophthalmic goiter, with compensatory hypertrophy following partial thyroidectomy and following the administration of anterior pituitary extracts are not essentially identical.

PHYSIOLOGY

Prior to the publication of Gull's observations (1874), "On a cretinoid state supervening in adult life in women," the function of the thyroid was either speculative—that its secretion moistened the larynx, that it served to round out the neck, that it acted as a vascular shunt for the cerebral circulation, that it aided in the formation of erythrocytes, that it neutralized toxins—or was confused with the functions of the parathyroids. Gull definitely associated atrophy of the thyroid with dryness and loss of hair, thickness and dryness of the skin and a striking deterioration of mental and physical vigor. William Ord (1878) designated this condition myxedema, because he thought the brawny thickening of the subcutaneous tissues was due to excess mucin formation. In 1882 the Reverdin brothers, and in 1883 Theodore Kocher reported more fully on the effects of total thyroidectomy in man for the cure of goiter. Their observations established the first experimental confirmation of Gull's clinical pathological observations. Kocher designated the symptom-complex *cachexia strumipriva* and recognized that it was similar to Gull's spontaneous myxedema. Following these reports many species of animals were subjected to thyroidectomy. Thyroidectomized dogs (Schiff) and cats (Smith) usually developed an acute symptom-complex (tetany) and died within a week, while rabbits, sheep and goats lived indefinitely with little or no obvious effects. No real separation of the functions of the thyroid and parathyroid was possible until E. Gley (1891), physiologically speaking, discovered the external parathyroids in the rabbit and demonstrated that the acute symptoms and fatal outcome which earlier workers had noted in man and animals following thyroidectomy was due to the removal of the parathyroids. Nearly 20 years elapsed before separate functions for the parathyroids and thyroid glands were accepted by all workers. The recent work of Aub and his coworkers indicates that there is an important interrelation between the thyroid and parathyroid as regards calcium and phosphorus metabolism.

Since 1891 many species of mammals have been subjected to thyroidectomy in which the parathyroid factor has been excluded and the results are essentially identical in all species.

The next important contribution to thyroid physiology was in 1891 when Murray cured a case of Gull's disease by a series of injections of glycerol emulsion of fresh sheep's thyroid. This was an advanced case of 5 years' duration when treatment was begun. The patient died in 1919 at the age of 74, health having been maintained for 28 years. In 1892 Howitz, Mackenzie and Fox independently demonstrated that thyroid was equally effective in curing Gull's disease when administered orally either fresh, dried or cooked.

In 1895 Magnus-Levy, using the newly developed calorimeter, discovered that in Gull's disease the heat production was lowered as much as 40 per cent. Later work showed that this lowering of metabolism (O_2 consumption, CO_2, nonprotein nitrogen output and heat production) was the characteristic effect of thyroidectomy in all animals tested. The fall in metabolism begins in most animals between the fifth and seventh day after thyroidectomy and reaches its lowest level (30–40 per cent) in the rabbit between the 20th and 30th day and in man about the 60th day. This low level of metabolism may be maintained for years or as accessory thyroids or fragments regenerate the metabolism may rise, but usually not to the normal level.

In 1895 Magnus-Levy further showed that the oral administration of thyroid substance both to cases of Gull's disease and to normal persons caused a rise in metabolism. This observation determined the principal function of the thyroid as we understand it today, namely, that it provides a means for maintaining a higher rate of metabolism and for varying the rate to meet changing physiological needs. In 1912 Gudernatsch discovered that feeding thyroid to tadpoles caused metamorphosis to occur in from 3 to 5 days. This is still the most delicate test for the thyroid hormone. It was suggested that this effect might be due to raising the metabolism but work in recent years, particularly with the dinitrophenols, shows that these substances greatly increase the metabolism of tadpoles and cases of myxedema. This increased metabolism does not cause metamorphosis of tadpoles nor does it benefit cases of Gull's disease. The thyroid hormone, therefore, has a specific action not exhibited by iodides or by metabolism raising substances (adrenalin, dinitrophenol).

Chronologically the next important contribution to thyroid physiology was the demonstration by P. E. Smith (1916) and B. M. Allen (1917) that removal of the pituitary in tadpoles caused marked involution of the thyroid. Smith later devised the pharyngeal route for hypophysectomy in the rat and established that a hormonal factor from the anterior pituitary controlled the functional state of the thyroid.

Baumann and Hunt (1925) demonstrated that the thyroid hormone is necessary for Rubner's specific dynamic action of ingested foods. In thyroidectomized rabbits it disappears completely after 60 to 65 days, but can be restored in such rabbits by the administration of desiccated thyroid or thyroxine. While qualitatively the symptoms following thyroidectomy are similar in both immature and mature animals, the visible manifestations are much more striking in the immature animal. Superficially adult rabbits, sheep and goats may show very little change, which led the earlier workers to the conclusion that thyroidectomy was without much effect. Metabolism studies, however, showed the usual marked reduction in oxidation processes. In the young, this lowering of metabolism leads to stunting physical, mental and sexual development (cretinism).

The long life of thyroidectomized animals, the fact that animals below the lampreys do not have thyroids supports the conclusion that the gland is not essential for vegetative life.

The mode of action of thyroxine in increasing oxidation processes is unknown. The stimulation is a very general one since it increases the oxidation of proteins, fats and carbohydrates in their normal proportions as indicated by the respiratory quotient. Rohrer first showed that the oxygen consumption of minced liver, kidney and muscle of rats previously fed with desiccated thyroid was increased and Ahlgren showed that muscle from thyroidectomized animals consumed less oxygen than normal muscle. Most observations indicate that thyroxine added to excised tissue in vitro is without effect. The observation of Davis, de Costa and Hastings (1934) suggests that thyroxine increases the metabolism of the excised intact frog's heart but not of slices of the heart muscle. Verebely found that thyroxine was without effect on liver and muscle cells but raised the O_2 consumption of brain tissue and came to the conclusion that thyroxine probably exerts its action on the various somatic tissues by way of the central nervous system. Cannon and his coworkers found thyroxine effective in sympathectomized cats.

This conclusion is also supported by the observation of many workers including Abderhalden and Wertheimer, H. H. Meyer, Mansfield and Issekutz. Thyroxine does not raise the metabolism of frogs and reptiles. Issekutz found that thyroxine had no effect on the basal metabolism of spinal cats and assumed, as others had, that an intact central heat regulating mechanism was necessary for thyroxine action. This conception of thyroxine action would go far toward explaining its action on general metabolism, the long latent period, the relation of thyroxine to exophthalmos production, the purpose of a relatively high iodine content of the diencephalon and its possible correlation with adrenalin, that is, adrenalin acts through a peripheral sympathetic mechanism, while thyroxine may act through the vegetative centers in the hypothalmic region.

Diet. Diet influences the thyroid. Baumann and his coworkers (1896) first noted that feeding meat diets to dogs caused a decrease in the iodine store, while feeding sea fish (high in iodine) caused an increase in the iodine store of the thyroid. Watson showed that meat diets caused thyroid hypertrophy in rats. Marine and Lenhart found that liver, especially pig's liver, was the most potent of a large variety of meats in causing thyroid hypertrophy in dogs and also that this food was an important factor in the causation of goiter in brook trout. McCarrison, and later Mellanby, showed that fats also promote thyroid hypertrophy. All these studies indicate that protein and fats increase the rate of discharge of thyroxine and therefore thyroid activity is more necessary in their oxidation than in the oxidation of carbohydrates. This conclusion was also indicated by the rise in the respiratory quotient which normally follows thyroidectomy. Rachitogenic diets, whether of the high calcium and low phosphorus or high phosphorus and low calcium type, cause thyroid enlargement in dogs, rabbits and rats, providing the iodine intake is low. This action is independent of the protein, fat and carbohydrate in the diet. Such studies indicate that the ratios of calcium, magnesium and phosphorus in some important way influence thyroid function. Thompson has shown that calcium is increasingly effective in causing thyroid hyperplasia in rats the lower the iodine intake and she has recently demonstrated that a high calcium intake requires a much higher iodine intake in order to maintain a given level of the blood iodine.

BIOCHEMISTRY

Since Coindet (1820) first demonstrated the therapeutic value of iodine in the treatment of goiter many attempts to demonstrate this element in the thyroid have been made. Coindet's observation also made it possible quickly to establish that iodine was the active agent in the remedies (burnt sponge, salt, seaweed) that had been beneficially used for centuries in the treatment of goiter. The discovery by Murray (1891) of the curative effects of thyroid opotherapy in myxedema and the demonstration a year later that the active principle withstood drying and heating stimulated biochemists to attempt to isolate it. These efforts resulted in Baumann's announcement in 1895 that iodine in stable organic combination was a normal constituent of the thyroid. He obtained a brownish powder by prolonged hydrolysis with 10 per cent sulphuric acid which contained up to 10 per cent of iodine and named it *iodothyrin*, later *thyroidin*. Subsequent work showed that this method of hydrolysis destroyed part of the specific iodine compound. For some years following Baumann's discovery there was much discussion of the question whether iodine played an essential role in the active substance. Hutchinson (1896) concluded that the iodine containing colloid matter was the active substance: "The part which the iodine plays it plays in virtue of the form of combination in which it occurs in the colloid, not in virtue of its being iodine." Magnus-Levy (1897) had clearly demonstrated that iodides did not increase metabolism. Baumann and his pupils showed that iodine was present in dogs' thyroids in variable amounts and that feeding iodine increased the store, while feeding meat decreased the store. Baumann (1897) demonstrated that human thyroid glands from Hamburg contained larger amounts of iodine than glands obtained in Freiburg. Oswald (1897) demonstrated that the iodine content in general varied directly with the amount of colloid. Oswald (1899) also confirmed and extended Hutchinson's observation that the colloid was a globulin and contained practically all of the iodine. He recognized that this globulin could be rich or poor in iodine and introduced the terms "thyroglobulin" and "iodothyroglobulin." Marine and Williams (1908) and Marine and Lenhart (1909) showed that histologically the amount of colloid material in the follicle varied inversely with the degree of epithelial hypertrophy and also that the iodine content of the thyroid varied inversely with the degree of hyperplasia. The globulin content of the thyroid is roughly the same whether the gland is hyperplastic or colloid. In the actively hyperplastic gland the thyroglobulin is in the cells and is very poor in iodine, whereas in the normal or colloid gland (goiter) the thyroglobulin is mainly in the follicles and is usually, though not always, rich in iodine. The maximum store of the iodine in the mammalian thyroid is between 5 and 6 mg. per gram of dried gland, while the minimum may be inestimable traces. The minimum concentration necessary for the maintenance of normal structure appears to be strikingly constant in the domesticated mammals and averages around one tenth of 1 per cent dry weight. The relation of the iodine store to the histological structure of a few typical mammals is given in the following table, expressed in milligrams per gram of dried gland.

	Normal Stage	Hyperplastic Stage			Colloid or Resting Stage
		Early	Moderate	Marked	
Man	2.17	0.88	0.71	0.32	2.00
Dog	3.32	0.62	0.37	0.11	1.99
Sheep	2.47	....	0.40	0.01	3.00
Ox	3.46	1.65	....	0.19	....
Pig	2.51	1.10	....	....	2.35

The normal human thyroid weighs between 20 and 25 gm. and may contain as a maximum 1 mg. of iodine per gram of fresh tissue, while the average is about one half this amount. Iodine appears early in the fetal thyroid. Fenger demonstrated it in the fetal calf as early as the third month. There is also a definite seasonal variation in the iodine store (Seidell and Fenger), the store being lowest in early spring and highest in the late summer in cattle, sheep and pigs. Iodine fed to pregnant animals is quickly stored, both in the maternal and fetal thyroids and a depletion of iodine in the mother also reduces it in the fetus. Surviving thyroid in vitro has the same marked selective ability to take out and fix iodine (given as KI) from the circulating fluid as is seen in the thyroid in vivo. No other tissue has this capacity. So far as is known the thyroid is the only organ capable of elaborating the iodine containing hormone. Iodine is normally present in the blood. The normal amounts reported vary widely from 8 to 18 micrograms per 100 cc. The variations reported are probably due more to the methods used, none of which are satisfactory, than to the actual variations, and probably 5 to 10 gamma per cent would more nearly represent the normal variations. In general the blood iodine has been found higher than normal in most cases of Graves' disease, but not in all cases and it is below normal in myxedema and after thyroidectomy (Curtis et al). Also in endemic goiter districts the blood iodine is generally lower than that of non-goiter districts. The presence of iodine in the blood implies that iodine should be present in minute amounts in all tissues as originally claimed by Justus and now generally confirmed. However, certain tissues have much higher iodine values than others, though none has quantities remotely approaching that of the thyroid which normally contains probably one fifth of the body iodine. The ovaries, anterior pituitary and diencephalon contain more iodine than other organs. The form in which the iodine exists in the blood and tissues other than the thyroid is not known. It is interesting but unprofitable at present to speculate on the possible physiological importance of the concentration of iodine in the diencephalon, ovaries and pituitary, particularly in relation to the known interrelations of these organs.

Iodine balance. Attempts have been made to determine the minimum daily needs of iodine in the normal human subject by iodine balance studies, particularly by Von Fellenberg, Scheffer, and Curtis and his coworkers. Such studies entail great difficulties because of the small amounts of iodine involved and the methods available of estimating its excretion in the urine, feces, sweat, respired air and nasal secretions. The daily requirements for thyroxine iodine can be more accurately determined by the amount of thyroxine necessary to hold the basal metabolism of cases of myxedema to the normal level. This has been determined by Boothby and other workers at 160–200 gamma I_2 (approximately 0.31 mg. thyroxine). A large part of this thyroxine in normal persons is undoubtedly derived from the conservation of iodine in the body. Hence it would be desirable to know how much iodine is required to balance that lost daily through the excreta in normal persons—so-called iodine balance. Studies along these lines have given figures of 15–25 gamma per day as the minimum intake necessary to balance excretion (v. Fellenberg, Scheffer, Curtis et al). The figures have been obtained by determining over a period of some weeks the amount retained from a given daily intake and from the amounts excreted daily when the intake is reduced to as nearly nil as possible. The idea that there could be any constancy in the excretion of iodine under ordinary conditions seems so improbable to me that the physiological value of the data reported is problematical.

Returning to the attempts to isolate the active principle of the thyroid, all efforts to utilize the method of acid hydrolysis failed. Oswald tried barium hydroxide hydrolysis because Drechsel (1896) had used this method successfully in isolating iodogorgin from the axial skeleton of coral. Wheeler and Jamieson (1905) showed iodogorgin $3.5.3^1.5^1$. was diiodotyrosine. Oswald failed to obtain an active fraction because, as pointed out later by Harington, he discarded the acid insoluble portion with the barium sulphate. Hutchinson, Oswald and others, also were unsuccessful, in concentrating the active principle by means of peptic and tryptic digestion. Kendall (1913) again undertook to use the method of alkaline hydrolysis and showed that the iodine became increasingly dialyzable through celloidin membranes by carefully treating thyroid with sodium hydroxide. In 1914 Kendall, by hydrolyzing thyroid with 1 per cent sodium hydroxide in 90 per cent alcohol, was able to separate the iodine of the thyroid into two fractions which he designated A and B. Fraction A, or the acid insoluble, was physiologically active, while fraction B, or the acid soluble portion, was physiologically inactive. In 1916 Kendall announced the isolation from fraction A of a crystalline compound containing approximately 65 per cent of iodine and which physiologically produced the same effects as desiccated thyroid. The yields were exceedingly poor and his attempts to determine the structure from amounts available were unsuccessful but he thought it was a derivative of tryptophane. Nurnberg (1907) using Baumann's iodothyrin attempted to ascertain the iodine holding group of thyroglobulin. He was unsuccessful but certain reactions led him to suggest that the iodine was bound with tyrosine—probably as diiodotyrosine. In 1926 Harington improved the method of extracting thyroxine by returning to the use of barium hydroxide and was able to accumulate sufficient quantities to determine its empirical formula as $C_{15}H_{11}O_4NI_4$ and its structural formula as $3.5.3^1.5^1$. tetraido–4–(4^1-hydroxyphenoxy) phenyl α aminoproprionic acid. The organic nucleus he named thyronine.

Later work by Harington and Randall showed that thyronine was formed from two molecules of tyrosine with the loss of one molecule of a aminoproprionic acid and the two benzene rings joined by an ether linkage. In 1927 Harington and Barger synthesized thyroxine and showed that it had the same physiological action as natural thyroxine. Harington further showed that the acid soluble fraction, or the physiologically inactive iodine, earlier designated product B by Kendall, was diiodotyrosine and identical with that present in coral and sponge. Foster (1929) confirmed the occurrence of diiodotyrosine in the thyroid and was able to recover as much as 30 per cent of the total thyroid iodine as diiodotyrosine. It is of paleochemical interest that diiodotyrosine in protein combination is found in sponge and coral and may be the hormonal equivalent of thyroxine in these animals. Harington has estimated that diiodotyrosine on the average accounts for about 60 per cent of the thyroid iodine and thyroxine for 40 per cent. The proportion of these two compounds must obviously vary since diiodotyrosine is a stage in the synthesis of thyroxine and both substances are constituent amino acids of a specific globulin. These are the only two forms in which iodine has been found in the thyroid.

It is of interest to note that one may immunize an animal (rabbit) against ox iodothyroglobulin without affecting the physiological action of the hormone (Rosen and Marine) while with other hormones of a protein nature, such as parathormone, the anterior pituitary hormones and prolan appear to be, immunity eliminates their physiological activity. This shows that thyroxine is not an essential factor in the antigenic property of thyroglobulin while with the other hormones mentioned their antigenic properties are intimately connected with the physiologically active component of the protein. The synthesis of thyroxine by the thyroid requires hours while the storage of iodine in the surviving gland, both in vivo and vitro, is almost instantaneous. The form in which iodine is so quickly stored has not been determined but the work of Harington suggests that it may be bound with tyrosin. It is, however, firmly fixed so that prolonged perfusion will not wash it out if the cells are surviving. This is not true of other tissues. The first evidence of thyroxine formation in dogs' thyroid using the Gudernatsch tadpole test was obtained by Marine and Rogoff in about 8 hours after the intravenous injection of potassium iodide. It has been known since thyroxine was first available that when orally administered it is much less active than an equivalent amount of iodine in the form of desiccated thyroid or of iodothyroglobulin. This has been explained as due to its insolubility and hence its poor absorption. But Reed Hunt (1923) showed that when thyroxine was injected intravenously and iodine equivalent amounts of desiccated thyroid administered orally thyroxine was less active, thus establishing that the total iodine of thyroglobulin (thyroxine and diiodotyrosine) was physiologically active. Recently this fact has been confirmed in another way. Rihl, Oestreicher and Reiss (1936) showed that in the rabbit the pulse rate rises almost immediately after the injection of thyrotropic hormone, whereas when thyroxine is injected no effect on pulse rate is noted for more than 6 hours.

Salter and Lerner have suggested that diiodotyrosine is a cohormone and the thyroid hormone is complete only when diiodotyrosine and thyroxine are combined in the peptone molecule. In support of their hypothesis they have taken the relatively inactive (as tested on cases of myxedema) diiodotyrosine peptone residue from human thyroglobulin after removing most of the thyroxine and with the aid of pepsin have resynthesized a protein that was as effective in relieving myxedema as natural thyroglobulin in iodine equivalent doses. No explanation of what has happened under these conditions is available and the phenomenon is at present limited to the degradation products of thyroglobulin. Recently Ludwig and von Mutzenbecher have produced a substance chemically and physiologically nearly identical with thyroxine from a "non-specific protein" and iodine by hydrolyzing with weak alkali and heat. Heretofore only diiodotyrosine has been obtained by hydrolyzing non-specific protein plus iodine. Diiodotyrosine has only the action of iodides. It does not enhance the activity of thyroxine. Harington has combined the two amino acids into thyroxyl-diiodotyrosine and diiodotyrosyl-thyroxine without influencing the activity of contained thyroxine.

As the matter stands at present there is no need of assuming the existence in the thyroid of any active compounds other than those determined by iodine and thyronine. The combinations of iodine and thyronine are not the active principles but rather they are the components that confer specific properties upon a more or less complex protein fragment. This opinion is supported by the work of Harington and of Salter and his coworkers who have found thyroxine peptone more active than glycyl or allanyl thyroxine and these in turn somewhat more active than thyroxine in experiments where all three groups of substances were given intravenously. Much work obviously remains to be done to determine why thyroxine and diiodotyrosine combined in thyroglobulin is so much more active physiologically than the equivalent amount of crystalline thyroxine and diiodotyrosine.

INTERRELATIONS

This is probably the most important and certainly the most difficult problem in the thyroid physiology and pathology.

Thyroid-Gonads. This is the oldest known interrelationship of the thyroid. It is evidenced by the frequency of enlargement of the gland during menstruation, pregnancy, puberty and the menopause. As has already been mentioned, the ovary (but not testis) is relatively high in iodine, but the form in which it occurs and its possible function are wholly unknown. Removal of the gonads in the rabbit, dog, and rat usually leads to a slow involution of the thyroid, becoming manifest in about one month and associated with a slight reduction in total metabolism. In the guinea pig, on the other hand, gonadectomy causes a definite slight temporary activation and enlargement of the thyroid. Schockaert noted that emulsions of fresh ox anterior pituitary caused greater hypertrophy of the accessory male sex glands after thyroidectomy than before. I have pointed out that thyroidectomy in puberal rabbits hastens sexual maturation and greatly increases sexual activity in the males. Both of these types of reaction are apparently mediated through the anterior pituitary, as is further indicated by the fact that administration of oestrogenic substances or aqueous extracts of the male germinal epithelium prevent the thyroid enlargement in castrated guinea pigs, while desiccated thyroid prevents increased sexual activity of thyroidectomized male rabbits.

Thyroid-Thymus. Gudernatsch (1914) observed that thymus feeding increased the rate of growth of tadpoles, definitely retarded their metamorphosis and offered some protection to them against thyroid feeding. Hoskins obtained increase in the weight of the fetal thymus in guinea pigs whose mothers had been fed desiccated thyroid. Thyroidectomy definitely hastens thymus involution. Removal of the pituitary in dogs (Houssay) usually causes involution of the thymus. In diseases in which the thyroid activity is increased, as in exophthalmic goiter and acromegaly, thymus hypertrophy frequently occurs. All these effects could be interpreted as indicating some kind of an antagonism between thymus and thyroid hormones directly, or that they were mediated through the pituitary.

Thyroid-Parathyroids. The view that the parathyroids could function vicariously for the thyroid ended with Gley's demonstration that the so-called acute effects of thyroidectomy were due to the accompanying parathyroidectomy. The strikingly different symptoms of thyroidectomy and parathyroidectomy appeared to establish independent functions for these glands, but during the last decade evidence has accumulated indicating that they are at least complimentary in certain of their functions. The work on experimental rickets and particularly the work of Aub and his coworkers on exophthalmic goiter, thyroid feeding and myxedema shows that the thyroid is also concerned with the metabolism of calcium and phosphorus. The idea that excessive calcium ingestion was a causal factor in goiter was suggested a century ago (McClellan 1837). Aub has shown that in Graves' disease the calcium excretion is greatly increased while in myxedema it is lessened. Both thyroid feeding and the administration of the thyrotropic hormone greatly increase calcium excretion (Pugsley). Excessive thyroid feeding causes parathyroid hypertrophy. The increased thyroid activity in animals (dogs, rats, rabbits) on rachitogenic diets is associated with parathyroid hypertrophy. Thyroidectomy in rabbits on diets with normal Ca:P shows involution of the parathyroids. Baumann (unpublished) has shown that thyroidectomized rabbits on a high phosphorus and low calcium diet die more quickly than normals—suggesting that the thyroid enlargement on rachitogenic diets is protective in nature.

Thyroid-Chromaffin System. Some interrelation is indicated because of the facts that thyroxine and epinephrine are both derivatives of tyrosin and that both are powerful activators of metabolism through different mechanisms. Also as Goldberg and others have noted in thyroidectomized lambs—and we have confirmed in thyroidectomized rabbits—the adrenal medulla is definitely hypertrophic.

Asher and Flack (1911) showed that the blood pressure response in rabbits to a given dose of adrenalin was greater after stimulation of the thyroid nerve with intact thyroid than before. This has been confirmed, particularly by Cannon and his coworkers. Oswald has shown that a similar increase in the blood pressure response to adrenalin may be obtained by the intravenous injection of iodothyroglobulin and that the effect produced is proportional to the iodine content of the thyroglobulin injection. The Goetsch epinephrine test on exophthalmic goiter may be a clinical application of increased sensitivity to epinephrine. All these observations would support the original view of Asher and Flack that the thyroid hormone increases the irritability of the sympathetic nervous system and sensitizes the tissues innervated by it so that they are more susceptible to stimulation by epinephrine.

Thyroid-Pituitary. It has been known for nearly a century that individuals and animals with simple goiter have greatly enlarged anterior pituitaries. Niepce observed pituitaries in goitrous cretins weighing 2.4 gm. Rogowitsch (1889) was the first to produce experimentally hypertrophy of the anterior pituitary by removal of the thyroid in rabbits. This has been generally confirmed and a generalization may be made that in all states of thyroid insufficiency the anterior pituitary tends to undergo hypertrophy. Histologically all the elements of the anterior pituitary appear to take part in this hypertrophy, but the most striking single feature in rabbits is the degranulation of the acidophilic cells. The physiological significance of this thyroid-pituitary relationship became evident only after Allen and Smith devised methods for removing the pituitary in tadpoles and later by Smith developing a similar method for rats. Smith noted in tadpoles and in rats that hypophysectomy caused a marked reduction in the volume of the thyroid gland and that implants or injections of extracts of fresh anterior pituitary restored such atrophic thyroids to normal and even produced hypertrophy. Loeb, Aron, Schockaert, Uhlenhuth and many others have confirmed and extended this observation, using emulsions, acid and alkaline extracts of fresh and dried anterior pituitary. Eitel, Krebs and Loeser have also shown that anterior pituitary extract will cause hypertrophy of surviving thyroid cells in vitro. Marked hyperplasia of the thyroid, beginning within a few hours, occurs in susceptible animals. This is associated with a rapid loss of iodine from the thyroid and increase in the blood iodine, increase in metabolic rate and increased excretion of calcium and creatin. Exophthalmos also may develop in susceptible species (birds, guinea pigs). It was early pointed out that this symptom complex was strikingly similar to that seen in exophthalmic goiter. This thyroid stimulating substance is one of several specific hormones of the anterior pituitary (adrenotropic, growth promoting, lactogenic, gonadotropic and possibly splenotropic, parathyrotropic and thymotropic).

The thyrotropic factor has been partially separated from the others by Collip and his coworkers and the chemical and immunological data, while still meagre, indicate that the active substance is probably protein in nature. Sufficient work has now been done with the thyrotropic factor to justify the conclusion that the thyroid may be directly stimulated only by it, irrespective of whether the thyroid stimulation is associated with endemic goiter, with Graves' disease, with compensatory hypertrophy following partial thyroidectomy or with gonadectomy. While the anterior pituitary, therefore, exercises a controlling influence on the thyroid there is evidence that the thyroid exercises equally as profound an influence on the pituitary. Thus the anatomical changes in the anterior pituitary following thyroidectomy can be entirely prevented and cured by giving desiccated thyroid or thyroxine. Studies on the interrelations of the thyroid-pituitary have not appreciably advanced our knowledge as to the cause of myxedema or endemic goiter. The atrophy of the thyroid in myxedema is associated with enlargement of and increase in the thyroid stimulating factor of the pituitary, while in Graves' disease neither pituitary enlargement nor increase in the thyrotropic factor can be demonstrated. The relation of the thyroid secretion to the development of the exophthalmos of exophthalmic goiter has long been a controversial question. Prevailing opinion still favors the view that it is in some way connected with a hypersecretion of the thyroid hormone.

Without going into details regarding the mechanism by which chronic progressive exophthalmos is produced, one may say that in the lower animals the neuromuscular mechanism discovered by Mueller (1858) has not been disputed. In man and in monkeys, which have complete bony orbits and vestigial peri-orbital muscles, there must be the additional factor of weakness of the recti muscles. The first published work on the experimental production of exophthalmos was by Schockaert in young ducks and in the same year by Leo Loeb in guinea pigs following the injection of anterior pituitary extracts and muscles. About this time we reported the occurrence of progressive exophthalmos in rabbits which developed goiter on a diet of alfalfa hay and oats plus daily injections of acetonitrile. Assuming that the goiter was a manifestation of thyroid insufficiency and that exophthalmos was in some way connected with this insufficiency, we tried thyroidectomy and found that this produced exophthalmos much more quickly. We then tried the effect of pituitary extracts in normal and thyroidectomized guinea pigs and also found that exophthalmos was more easily produced after thyroidectomy than before. The importance of a relative or absolute thyroid insufficiency as one of the factors in the development of exophthalmos seems thoroughly established. Likewise the factor causing the exophthalmos must be present in the anterior pituitary, yet it does not occur in myxedema and cretinism, although both thyroid insufficiency and pituitary hyperactivity are present. Obviously other factors are involved. In the rabbit, and in man too, sex plays a rôle. It is much more frequent in the males, and gonadectomy in the rabbit both lessens the incidence and causes a regression of an existing exophthalmos. It is possible that oestrin is the factor that protects the female by preventing pituitary overactivity. Thyroid therapy is effective both in preventing and in curing this form of exophthalmos in rabbits and guinea pigs (and to some extent in human exophthalmos). Exophthalmos cannot be produced after the sympathetic pathway to the eye has been divided (Horner's syndrome) which indicates that it is dependent upon the stimulation of a sympathetic center in the central nervous system—probably the hypothalamus. The high iodine content of this portion of the brain may be significant in this connection. Thus exophthalmos would appear to be dependent upon an increased irritability of the sympathetic center which is determined by the concentration of thyroxine, thyrotropic hormone, certain salts (Ca, Mg, P) and probably other hormones bathing it. If this should be shown to be the mechanism of exophthalmos production it would be an additional factor in favor of the central action of thyroxine as well as the demonstration of another important thyroid pituitary interrelation.

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Genital Abnormalities

This exceptionally thorough treatment of intersexes was originally conceived by the author as merely a presentation of his own clinical and surgical cases of remarkable genital anomalies, but grew eventually into a complete discussion, embryological, clinical and surgical, of the entire problem of anatomic, pathologic, endocrine and physiologic abnormalities of the sex functions. The bulk of the volume is given over to a complete discussion of hermaphroditism. The twenty cases of true hermaphroditism (one of them reported by the author himself) which have been accepted as proved microscopically are presented in detail. Pseudohermaphroditism, occurring in one out of 1,000 individuals, in whom the gonads of only one sex are present, but the abnormalities of the external genitalia are such that doubt exists as to the true sex, is treated in detail, with many personal case histories. Among the other anomalies discussed are the adreno-genital syndrome, hyper- and hypogenitalism, gynecomastia, hypo- and epispadias, cryptorchidism, and atresia ani urethralis. The volume is beautifully and extensively illustrated with photomicrographs, surgical drawings and photographs. Biologists, physiologists, endocrinologists, physicians and surgeons will find the book of absorbing interest, and should put it on their "must" lists.

—L. H. S.

Genital Abnormalities, Hermaphroditism and Related Adrenal Diseases, by Hugh Hampton Young. xli+649 pp. Baltimore, The Williams and Wilkins Co., 1937. $10.00.

HORMONES OF THE ADRENAL GLAND*

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The adrenals were first described by Eustachius in 1563 but it was not until 1855 that Addison, an English physician, published a clue as to their function. He was able to associate a certain group of symptoms with disease of these glands. Fatigue, pigmentation and digestive disturbances were most prominent. His observations focused attention on the vital nature of these organs. Very soon it was proven by experiments on animals that the adrenals are necessary for life. The next important contribution came in 1894 when Oliver and Schafer demonstrated that an extract of the adrenal produced a marked rise in blood pressure. This was due to a substance obtained from the central part or medulla of the gland. Abel isolated the benzoyl compound of this substance and then Takamine and Aldrich, working independently, isolated the active principle by a method which was commercially feasible. Abel introduced the name epinephrin and Takamine that of adrenalin for this new compound. Its synthesis was accomplished by Stoltz in 1904.

SECRETION OF EPINEPHRIN

One can determine the amount of epinephrin in the adrenals by removing and extracting them, but that gives no information as to the amount normally secreted into the blood stream. This can be determined, however, by collecting the blood as it pours from the gland, and then assaying this blood for its epinephrin content. By cutting the sensory nerves of the region concerned in preparing the adrenal vein for cannulation, it is possible at a later date to carry out this procedure without the use of anesthesia. Inhibition of a contracting piece of intestine is used in the assay of the epinephrin. Satake, Watanabe and Sugawara found that during serene existence 0.00003–0.0001 mg. is secreted per min. per kg. This would amount to 0.4–1.4 mg. per day in a 10 kg. dog. If man secreted a proportionate amount the value attained would be 3–10 mg.

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*Aided in part by a grant from The Rockefeller Foundation.

in a day. However, without actual determination we do not know whether such an assumption is justified. Some investigators have obtained higher values than those given by Satake et al. Differences in the method employed as well as the conditions of the experiment may explain the discrepancy. It is difficult to prove that this amount of epinephrin has a physiological effect when secreted in the general circulation over a period of twenty-four hours, although if released at one time the effect would be lethal.

Serenity is often interrupted by stimuli which will increase the output of epinephrin. Exercise as moderate as walking produces an appreciable effect. Cold by its stimulation of sense organs may cause a decided increase. Emotional excitement may have a marked influence. Exposure to heat intense enough to cause a decided rise in body temperature may lead to a seven-fold increase in the output. Hemorrhage in which as much as one-third of the blood volume is lost causes a five-fold increase. Blood pressure maintained at shock level (40 mm. Hg) for one hour or longer will set free a thirty-fold increase. Marked reduction in blood sugar also increases the epinephrin output. Thus insulin evokes an outpouring of epinephrin which in turn raises the blood sugar. This explains the greater sensitiveness to insulin when the adrenal medullae are destroyed. These merely serve as examples of the wide variety of influences which affect the output of epinephrin.

EFFECT OF EPINEPHRIN

The amount of epinephrin secreted under physiological stimulation is enough to produce demonstrable physiological effect. One notes first the change in circulation. The heart is stimulated; blood vessels in the skin, in the mucous membranes and some abdominal organs are constricted, while those in skeletal muscle are dilated. In spite of these effects there is no evidence that epinephrin plays a part in the maintenance of normal blood pressure. Under the influence of epinephrin the spleen forces more red cells into active circulation. Blood coagulation is accelerated. The bronchioles are dilated permitting freer exchange of air with the lungs. Reduction in blood flow and inhibition of movement in the alimentary canal retard digestion. Epinephrin mobilizes the carbohydrates in the body as shown in the diagram (Fig. 1). Blood sugar is increased at the expense of liver glycogen stores while muscle glycogen is transformed into lactic acid which is later carried to the liver and transformed into glycogen. At the same time the utilization of carbohydrates is increased. When the concentration of epinephrin becomes sufficient general metabolism is increased.

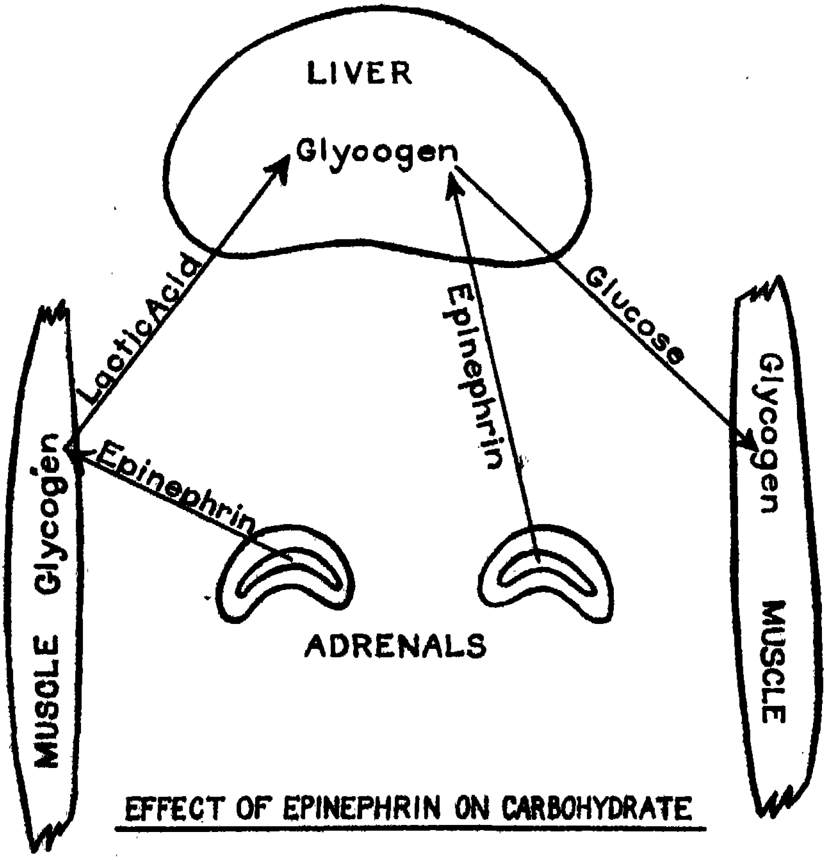

Fig. 1. Effect of epinephrin on carbohydrate.

A careful survey shows us that epinephrin acts on those tissues supplied by the sympathetic nervous system and in the same manner that this system does, stimulating where the latter stimulates and inhibiting where the latter inhibits.

Epinephrin action is fleeting. Any continued effect through its influence, therefore, must be sustained through continued secretion. Thyroxin increases the sensitiveness to epinephrin while thyroidectomy decreases the response as much as fifty per cent.

The total amount of epinephrin in both adrenals of a man is about 10 mg. This much or more may be secreted in 24 hours. Therefore there must be constant renewal. From experiments on animals it has been shown that it is difficult to exhaust the supply. Certain poisons like diphtheria toxin do this most effectively. Severe infections, starvation, convulsive doses of insulin and exophthalmic goiter also cause marked depletion (Corbett).

FUNCTION OF THE MEDULLA

The medulla through its secretion of epinephrin reinforces the action of the sympathetic nervous system. In times of stress its influence is most marked. This led Cannon to propose the emergency theory of the medulla. In the reactions of combat, flight or major emotions epinephrin helps to mobilize the resources of the organism for the emergency. However, epinephrin may influence the organism to a lesser degree in less strenuous states.

TUMOR OF MEDULLA

Occasionally a tumor may develop in the medulla. The symptoms are hypertension, headache, palpitation, perspiration, vomiting, tremor and rapid breathing which most often occur at intervals. The attacks may last a few minutes or longer and the blood pressure rise to 180 mm. Hg or more. Death may occur from pulmonary edema. The release of excessive amounts of epinephrin account for the symptoms produced. Removal of the tumor leads to disappearance of the symptoms. Such tumors have been found to contain much larger amounts of epinephrin than that found in a normal gland.

ADRENAL CORTEX

It has been known for eighty years that the adrenal is vital to the organism, but not until 1917 (Wheeler and Vincent) was it shown that only the outer part, the cortex, is essential to life.

No direct proof of a vital hormone of the cortex was published until 1927, when two groups of investigators, one in Cleveland (Rogoff and Stewart) and the other at Buffalo (Hartman, MacArthur and Hartman) demonstrated that an extract of the adrenal cortex could prolong the lives of completely adrenalectomized animals. The extract prepared by the second group was free from epinephrin. The hormone essential to life was named interrenalin by the Cleveland group and cortin by the Buffalo group. Beginning in 1930 improvements in the method of preparation were described by Swingle and Pfiffner and by Hartman and Brownell (1). Not only is it possible to maintain the lives of adrenalectomized animals indefinitely with such extracts, but they frequently can be revived from collapse. The first severe case of Addison's disease kept alive by cortin was described by Hartman, Aaron and Culp. He was revived from a comatose condition and survived until he contracted pneumonia nearly eight months later.

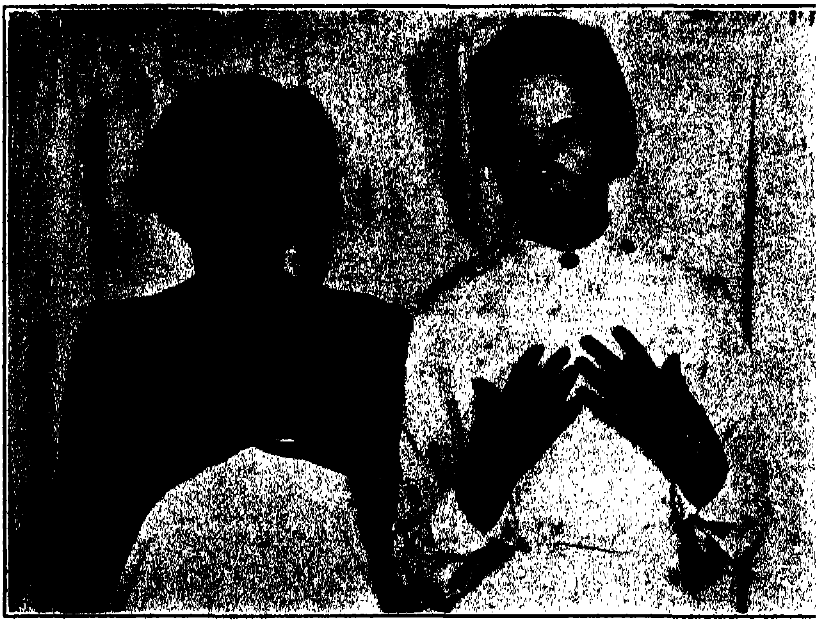

Fig. 2. Shows pigmentation of Addison's disease in contrast to a normal subject. Note the general bronzing with black freckles especially on the face.

In spite of numerous reports to the contrary, cortin has not yet been isolated. The most recent report of DeFremery, Laqueur, Reichstein, Spanhoff and Ulydert claims a highly active crystalline cortical hormone which melts at 180°–182°. Their animal test is not entirely convincing because they used 0.6–2.5 mg. of their substance with added salt in dogs weighing 11–18 kg. Without added salt ten times as much was required.

Swingle and Pfiffner's non-crystalline preparation requires 0.03–0.045 mg. for dogs of corresponding size without added salt. Our best preparation which is amorphous would require 0.011–0.03 mg. for dogs of corresponding size.

All evidence for the existence of cortical hormones depends upon biological tests. So far the only critical test for the vital hormone is the ability to maintain the normal activities of completely adrenalectomized animals. There may be other hormones not yet recognized. This possibility makes it desirable to analyze the responses of normal animals as well as adrenalectomized animals to different preparations from the adrenal cortex.

INFLUENCE ON PIGMENTATION

Although pigmentation never occurs in the adrenal insufficiency of animals it is often present in man (Fig. 2). It may begin at any time in the course of development of Addison's disease or it may be absent altogether. In color it ranges from tan to negroid; occasionally it is gray or olive. The intensity is greatest in regions exposed to light or pressure. Its distribution varies from a uniform shading over large areas to blotches or freckles. It may extend to the mucous membranes. The symptoms of the disease bear no direct relation to the intensity of the pigmentation. Treatment with cortical extract may cause a slow disappearance of pigmentation. Whether pigmentation is due to cortin insufficiency or to the absence of some other substance probably can not be determined until pure hormone is available.

RELATION OF CORTIN TO ELECTROLYTE AND FLUID SHIFT

One of the first signs of adrenal insufficiency is loss of desire for food and water and reduction in absorption from the alimentary canal. This lowers the intake of water and salts. In normal individuals adjustments are made for such reductions without difficulty, the salt and water of the body being conserved through decreased excretion by the kidney. In cortical insufficiency the kidney allows sodium chloride to escape in larger amounts than usual (Fig. 3) so that the body reserve is seriously depleted. The volume of the blood plasma becomes reduced due to loss of water through the kidneys, although at first some of this water escapes into the tissues. Later the tissues also become depleted (Fig. 4). The ability of cortin to restore the plasma volume without administration of water and salt indicates that the changes are not limited to the kidney. Cortin must bring about a readjustment in the distribution of the electrolytes and fluid within the body itself.

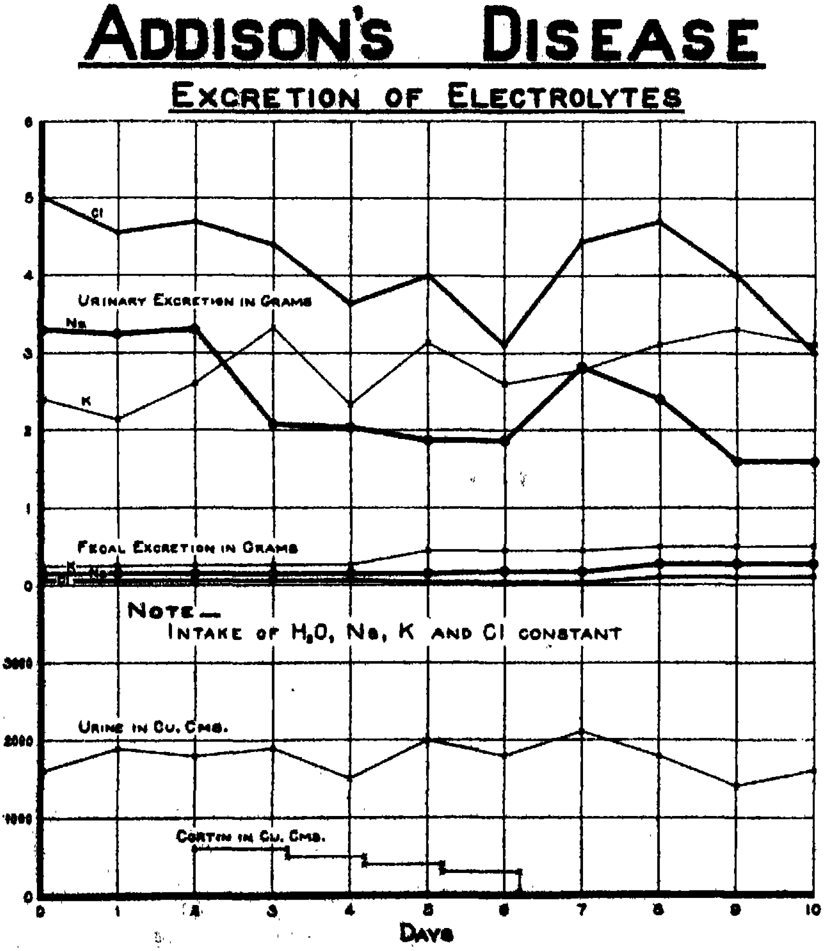

Fig. 3. Renal excretion of electrolytes in a case of Addison's disease. Note that Na and Cl excretion is reduced while the K excretion is increased after cortin injections.

At times it is possible to effect restoration in a subject who is in collapse. However, complete restoration usually requires the administration of water and salt, as well as cortin. Any demand which increases the need for fluid shift is poorly met in cortical insufficiency. Hemorrhage which may be insignificant in the normal subject may produce collapse in insufficiency. Resistance to heat is much diminished. Water fails to shift as readily from the reservoirs such as skin and liver, resulting in less available water for evaporation and heat loss. Cortical insufficient subjects develop serious symptoms and succumb more readily to heat than do normals (Hartman, Brownell and Lockwood).

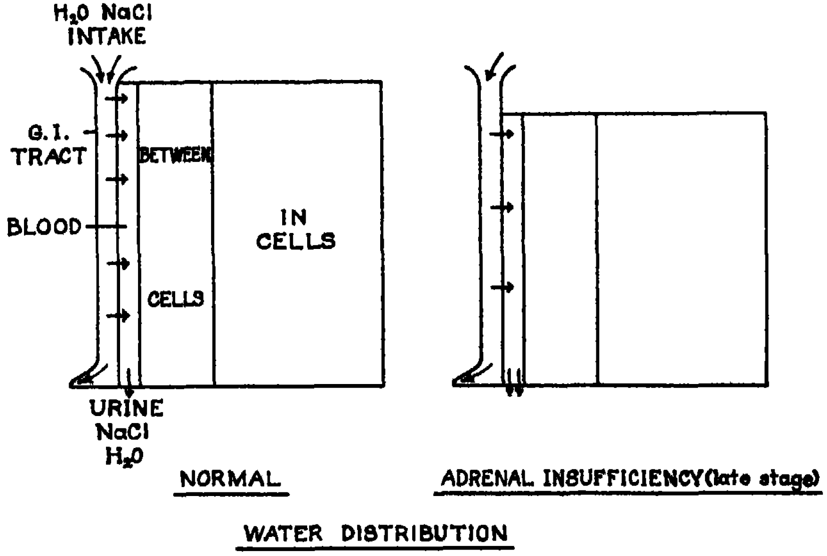

Fig. 4. Distribution of water in well established adrenal insufficiency compared with the normal.

Increase in the NaCl intake may ameliorate the symptoms of early cortical insufficiency but it is unavailing in the late stage. Cortin not only enables the kidney to maintain the threshold for electrolyte excretion which exists under normal conditions, but when injected into normal individuals in large amounts raises the threshold above normal for NaCl but lowers that for potassium. These effects persist for several hours following a single injection.

Sodium chloride depletion in itself may cause the development of symptoms (McCance). These are weakness, lassitude, cramps and severe cardio-respiratory distress on exertion.

RELATION TO THE NERVOUS SYSTEM

In adrenal insufficiency whether experimental or pathological (Addison's disease), symptoms develop which indicate marked changes in the nervous function. Not only does fatigue come on more easily but there is disinclination to muscular or mental effort. Loss in interest in surroundings may lead to a state of inertia which verges on coma. On the other hand the subject may be easily irritated and may even become disoriented. The cerebral manifestations especially in the late stage of Addison's disease may be treated by the psychiatrist without recognition of the disease. The insomnia, exhaustion, incompetence and confusion are no different than may appear in conditions not involving the adrenal. The administration of cortical extract corrects these conditions when due to cortical insufficiency. The effect might be the result of action on some primary function which indirectly influenced the nervous system such as the distribution of electrolytes or it might be due to direct action on the nervous system itself. However, observations of Hartman and Lockwood seem to show that cortin affects the reflexes directly because they become more readily fatigued in adrenalectomized rats without cortin than in similarly operated animals with cortin. This hormone influences the nervous system in conditions without obvious adrenal insufficiency. In some cases in which there is organic neurological change cortin improves the motor functions and the mental status. Fatigue is diminished with a concomitant increase in strength. Myotonic manifestations and fibrillation, when present, are decreased. A sense of well-being replaces depression and irritability disappears. (Hartman, Beck and Thorn.) Normal individuals at times respond, the immediate effect being drowsiness and release of nervous tension. These effects are not due to suggestion because sheep in a state of neurosis due to overtaxing the nervous system in conditioned reflex experiments, show marked improvement under cortin therapy. (Liddell, Anderson, Kotyuka and Hartman.) This neurosis is characterized by extreme excitement, uncooperative behavior and spontaneous nervous twitching movements of the limb concerned in the reaction. Administration of cortical extract increased the vigor of the conditioned reflex and decreased the frequency of the nervous movements. The improvement persisted for more than three weeks after the last injection. Increased resistance to fatigue, which persisted longer than 47 days after cortical extract injections were discontinued, had previously been observed in a patient with muscular dystrophy (Hartman and Thorn). The assumption is made that cortin is responsible for these effects.

EFFECT ON METABOLISM

Metabolism is lowered as much as 25 per cent in cortical insufficiency. In other words the sum of the chemical changes in the body is reduced that much under basal conditions. When there is stress the difference is augmented. Upon exposure to cold adrenalectomized animals may produce the extra heat required for a short time but this finally fails so that the temperature drops. Reflex activity is involved in the reaction to cold. It is possible that eventually the failure of the body musculature to produce more heat is due in part to fatigue of these reflexes as well as to depleted carbohydrate reserves. In adrenalectomized animals not exposed to cold there is a reduction in carbohydrate stores. This is not entirely accounted for by the lowered food intake because a twenty-four hour fast causes almost complete disappearance of liver glycogen in operated animals but not in normal animals. The blood sugar of the operated animals is also lowered. Muscle glycogen eventually falls. Adrenalectomized dogs whose electrolytes are maintained with cortin or without cortin by the administration of large amounts of sodium salts show a decided fall in blood sugar (Harrop et al.). This suggests that there may be another hormone which is concerned with carbohydrate metabolism. Such a view is supported by Long, who found that cortin did not maintain diabetes undiminished in adrenalectomized-depancreatized cats. We (Hartman and Brownell (2)) have been able to maintain the high blood sugar and sugar excretion in the urine in similar fed animals by large amounts of cortin provided the animals had not lost too much weight. In a fed dog with both adrenals and pancreas removed it has also been possible to maintain the high sugar values with cortin but the ketosis was much diminished (unpublished work of K. A. Brownell). The enlargement of the cortex produced by injections of insulin (Riddle) also gives evidence of a relation of the cortex to carbohydrate metabolism.

Cortical extract has an effect on respiratory metabolism in normal individuals according to observations of Hitchcock and Grubbs in our laboratory. It reduces the oxygen consumption under conditions requiring more oxygen as in moderate exercise. The average reduction in eleven subjects was nearly 6 per cent during standing and about 14 per cent during walking. This seems to indicate an increase in muscular efficiency. The effect persists for several days after the extract is discontinued. This persistence reminds one of the after effect in neurotic sheep and in occasional patients. (See nervous system.)

VITAMINS

It has been known for a long time that the adrenal cortex hypertrophies in vitamin B_1 and C deficiencies. Another suggestion of a relation between the cortex and vitamin C is the observation that in late stages of adrenal insufficiency hemorrhages may occur from the gums and in the alimentary canal, a condition similar to that found in scurvy. We (Lockwood and Hartman) have studied the effect of cortical extracts in deficiencies of these vitamins. In the preparation of extract ethyl ether was employed at one stage to avoid inclusion of vitamins B^1 and C which are found in the cortex. These vitamins are insoluble in ether (Sherman and Smith). Additional evidence of the absence of vitamin C was obtained by the spectrographic method (Lockwood, Swan and Hartman).

Injection of cortical extract delayed the weight loss and postponed the onset of signs and symptoms in both avitaminosis B_1 and C. In order, as we thought, to reduce the active adrenal tissue we removed one adrenal in some animals. The results were just the reverse of what was expected. On both the B_1 and C free diets such an operation produced an effect similar to the injection of cortical extract. However, this did not occur if we waited about three weeks after the adrenalectomy before starting the vitamin free diet. It seemed that there was an overproduction of this ameliorating substance in the remaining adrenal for about three weeks after the operation.

Extract is most effective early in the avitaminosis when some vitamin from the pre-experimental period is still available in the organism. It is also more effective when a partial protective amount of the vitamin is fed. These observations suggest that cortical extract aids in the utilization of vitamins B_1 and C. Our extract contained significant amounts of cortin as judged by tests on adrenalectomized animals. Cortin or some unknown substance in the extract must have been responsible for the effects in vitamin deficiencies.

CORTILACTIN

Adequate amounts of cortical extract enable adrenalectomized animals to give birth to young. Some time ago we (Brownell, Lockwood and Hartman) reported that cortical extract could be divided into two fractions, one containing cortin and the other a substance (cortilactin) necessary for lactation. It was possible to make this separation only under certain conditions. Cortex was extracted with 90 per cent alcohol. After removing the alcohol by vacuum distillation from the resulting extract the residue was taken up with ethyl ether. Ether was removed in vacuo from the ether extract. The residue was extracted with 70 per cent alcohol. The resulting solution was chilled to −12° C. The lipids which were precipitated contained the factor necessary for lactation. Cortin remained in solution. Ordinary methods of preparing cortical extract do not separate the lactation factor from cortin. Cortin alone does not seem to enable adrenalectomized rats to lactate sufficiently. If cortilactin is added or if it has not been separated from cortin in the preparation of the extract, lactation is well supported. A positive effect on milk secretion has been obtained in the human being with cortilactin (unpublished work of Thorn and Hartman). Eight patients carefully controlled in the hospital have been studied. All were secreting very inadequate amounts of milk. Six of these showed increased milk production within 48 hours after starting the injections. The remaining two developed the typical sensation of tingling in the breast but no milk secretion. In one of the patients who responded with increased milk secretion, the amount of milk secreted fell to zero after cortilactin was discontinued.

CORTIPRESSIN

Although the blood pressure of adrenalectomized animals is maintained by cortin, in some cases of Addison's disease seemingly adequate cortin treatment often does not re-establish the normal blood pressure level. Therefore it is possible that an additional factor is lacking. Looney and Darnell have found that a glycerol extract of the adrenal cortex administered by mouth in the human-being causes a prolonged increase in blood pressure. The marked rise occurs after four or five days and disappears in ten to fourteen days after withdrawal. The active substance is insoluble in fat solvents and is more stable toward alkali than is cortin. They have named the substance cortipressin. We have employed a glycerol extract of the cortex in the treatment of Addison's disease but the effect on blood pressure is not striking.

ADRENOSTERON

Reichstein has isolated a compound which has about one-fifth the potency of the male sex hormone, androsteron. He calls the new compound adrenosteron. Frequently tumors of the adrenal cortex are found in cases of abnormal masculine development. Young boys so affected are precocious in both growth and sexual development. Females so affected change to the masculine type. The distribution of the hair and the character of the voice change, while menstruation ceases if it has begun. Removal of the tumor is followed by reversion to normal. Excessive production of adrenosteron might explain the changes resulting from cortical tumors.

CONTROL OF THE ADRENAL

Although the adrenal is well supplied with nerve fibers, their influence seems to be confined to the medulla. How is the cortex controlled? Within six days after hypophysectomy the adrenals of the rat are reduced to one-half the weight of the controls; maximum atrophy is reached in thirty days. This is largely due to changes in the cortex. All zones show marked reduction in the cytoplasm (Smith). The atrophied cortex still produces the vital hormone for if removed the animal dies of adrenal insufficiency. However, its production is probably inadequate because symptoms of cortical insufficiency develop from hypophysectomy. In hypophysectomized rats removal of one adrenal does not lead to hypertrophy of the remaining gland as it does in normal animals (Reiss, Balint and Aronson). Pituitary preparations restore degenerating adrenal cortex or, in normal animals, can increase the size of the cortex as much as two-fold (Emery and Atwell). Thus it has been demonstrated that the pituitary plays a major role in cortical control through its production of the adrenotropic hormone.

RESPONSE OF THE CORTEX TO STRESS

It is well known that in adrenal insufficiency there is greater susceptibility to infections, toxins, cold, heat, exercise and trauma. In order that these conditions be met considerably more cortin is required. Cortin, therefore, has an emergency function as well as a sustaining function. Various stresses if repeated with sufficient frequency can increase the weight of the adrenals. Examples are shown in Fig. 5 in which the relative adrenal weights of the adrenals of rats under stress are compared with control litter mates. The cortex is largely responsible for the increase in weight.

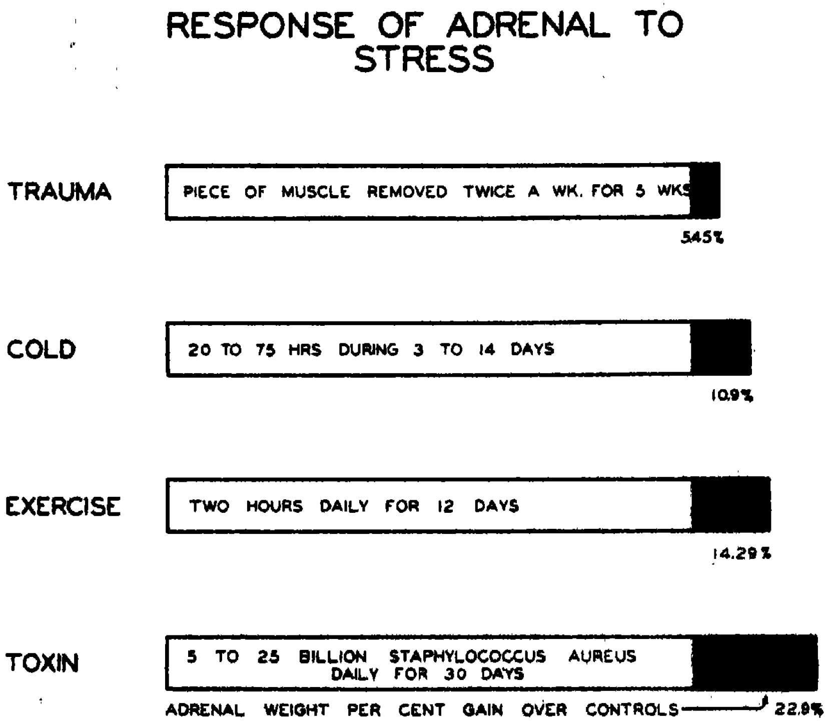

Fig. 5. Response of adrenal to stress (rat), gain shown in black.

Although a part of the adrenal tissue is adequate to maintain the organism under quiet conditions, stress requires the functioning of all of the adrenal tissue. Rats with one adrenal removed are unable to produce as much heat when exposed to cold as when both adrenals are intact. For this reason they do not withstand cold so well (Horvath), Fig. 6.

COMPENSATORY HYPERTROPHY

If adrenal tissue is destroyed by disease or other cause, does the remaining tissue have the power to regenerate and if so can it replace the amount of tissue lost? The need for reserve adrenal tissue in stress makes this a very important question.

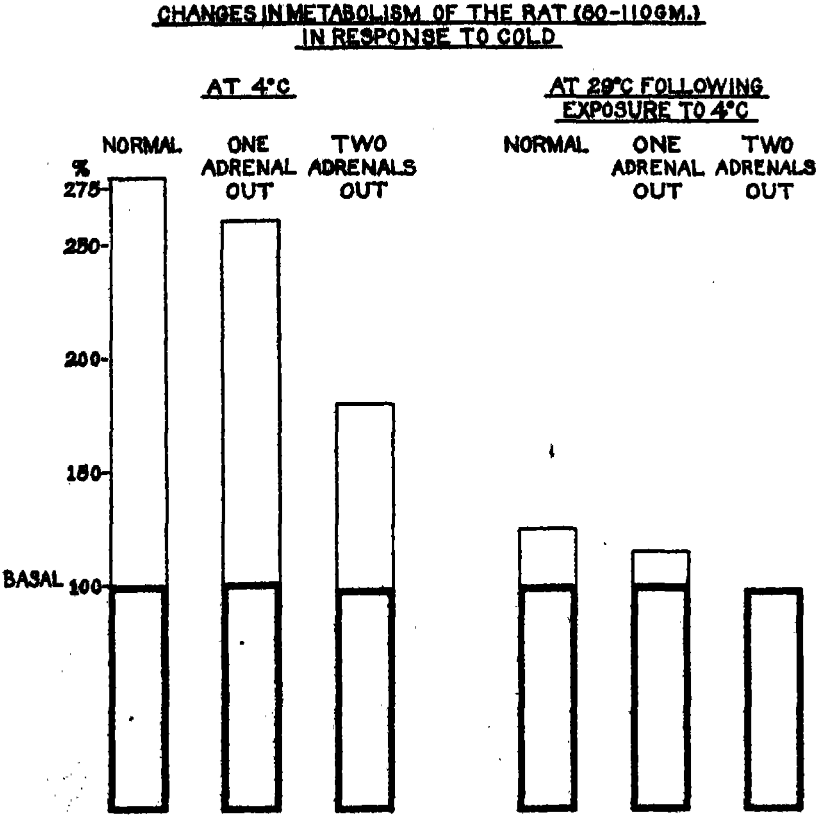

Fig. 6. Changes in metabolism of the rat in response to cold.

The failure to find evidence of regeneration of adrenal tissue at autopsy in Addison's disease may be explained by the assumption that had there been regeneration the patient would not have come to autopsy. It seems necessary to use animals to test the possibility of hypertrophy.

In young rats removal of one adrenal results in the hypertrophy of the remaining gland on the average of sixty per cent. (MacKay and MacKay.) This is far short of compensation.

Destruction of part of the adrenal tissue by cautery in cats is not followed by significant hypertrophy (Hartman). It is possible that the development of scar tissue from cautery prevented regeneration. Therefore, experiments were performed in which part of the left adrenal was removed by a sharp scalpel. The piece removed was measured and weighed. Months later the right adrenal was removed, measured and weighed. From two to nine months after removal of the right adrenal the remainder of the left adrenal was removed, measured

TABLE I

Sex	Time (Days) Elapsed After		Body Weight		Weight of Adrenal	
	First Operation	Second Operation	Original gm.	At End gm.	Right gm.	Left gm.
F	126	64	2050	1340 (died)		0.055
						0.044
						0.099
M	401	281	3675	4260		0.112
						0.125
					0.175	0.237
F	329	268	1800	2380		0.055
						0.089
					0.121	0.144
F	333	216	1475	2225		0.063
						0.038
					0.114	0.101
M	354	294	1995	3100		0.067
						0.104
					0.149	0.171
F	399	282	2650	3150		0.168
						0.119
					0.245	0.287
M	399	281	3300	3880		0.086
						0.075
					0.160	0.161

and weighed, the accompanying table (Table I) presents the results. The weights of the first and second pieces of the left adrenal were added together. A comparison of this sum with the weight of the right adrenal shows that there could not have been a great amount of regeneration if one assumes that the right and left glands are not greatly different in size. The piece remaining in situ never regenerates enough to compensate in size for the tissue removed. When accessory adrenals are present in those animals which survive for a considerable time following adrenalectomy, the accessories do not become very large. In four cats the largest which we have observed (300 days after complete adrenalectomy) has been 55 mg. We are forced to conclude that although a small amount of regeneration of adrenal tissue takes place, there is never complete compensation.

TABLE II

Hormones	Function
Epinephrin	Reinforces sympathetic nervous system.
Cortin	Maintains electrolyte balance. Required by nervous system. Aids in utilization of Vitamins B_1 and C. Necessary in metabolism of carbohydrate and fat.
Cortilactin	Required for lactation under certain conditions.
Cortipressin	Raises blood pressure.
Adrenosteron	As male sex hormone

CONCLUSION

Two hormones of the adrenal are definitely established. One, epinephrin, is the only hormone indicated from the medulla. The other, cortin, is but one of a number indicated from the cortex (Table II). The function of cortin is somewhat indefinite. It maintains electrolyte balance and seems to be required by the nervous system. It may be the factor which aids in the utilization of vitamins B_1 and C. Some other factor in addition to cortin seems to be necessary for the metabolism of carbohydrate and fat. Other provisional hormones are cortilactin, cortipressin and adrenosteron. Further purification of the factors in the cortex will be required to establish some of them as hormones.

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Religion

This volume is the twenty-fourth edition of a popular book by a scientific man, a book on religion by the director of the Psychological Service Center of New York. As these many editions were issued in a year and a half, the book may fairly be classified as a "best seller." Dr. Link tells how, as a practising psychologist, he found that the greatest lack in the personal development of masses of people consisted precisely in the lack of a purpose, of an ideal, such as religion would give them. Thus, without entering into the philosophical problem of the existence of God, he found the Bible to be the best text-book extant on morality and character development. In his own words: "Psychology differs from all other sciences in this important respect. Whereas the other sciences have taught us that our beliefs about nature were wrong, psychology is proving that many of the ancient ideas and precepts about the development of a good character and personality were right." Dr. Link's own work is in the field of individual psychology, though he works through general means of adaptation and attacks the psychoanalysts with real bitterness. When he applies his ideas, however, to the field of education and of social reform, many of us would differ with him, on the ground that his conclusions do not follow from his personality studies, mental testing, and similar work in an unrelated field. He holds, for example, that education tends to delay character development rather than advance it because it makes the pupil dependent on the teacher. In the same way he objects to extension of government services as making individuals less self-reliant, whereas some of us feel that starvation is more immediate than character development.

—Lee J. Levinger.

The Return to Religion, by Henry C. Link. New York, the Macmillan Co., 1936. $1.75.

THE HORMONES OF THE ANTERIOR PITUITARY

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INTRODUCTION

This Society—"devoted to the promotion of research in science"—may very reasonably ask a speaker to begin his address with a statement of the general or wider meaning of current advances in the field for which he is to speak. Perhaps the usefulness of such a general statement tonight is increased by the circumstance that the present discussion concludes a symposium of 10 lectures on Hormones which this Chapter of Sigma Xi has been resourceful enough to arrange and present within the year. Again, those several earlier and related discussions can very notably reinforce any general statement which might be made concerning advances in the study of the anterior pituitary hormones alone.

Almost too obvious to require mention in such a general statement is the practical certainty that present and future advances in our knowledge of the hormones will make medicine more effective in dealing with at least several diseases and incapacities of man and animals. But rightly notable here, because rather less evident, are two somewhat related things: First, some conditions not classifiable as disease but as subnormal developments of body or mind—such as small stature and some forms of dull mentality—will probably prove more amenable to favorable influence by hormones than from any other therapeutic source. Second, the hormones have already provided the essential basis for an understanding of the cycles and reproductive adjustments peculiar to women, although 15 years ago not one of the several hormones involved in the production of those cycles had been isolated or suitably measured. Another 15 years should add very useful elements of control to our present quite gratifying degree of comprehension of those cyclical adjustments to which one-half of mankind is subjected during much of the span of life.

Further—and this point is of interest to investigators in all branches of science represented in this Society—advancing knowledge of the hormones is enabling us to begin to see and comprehend the mechanisms by which our own complex bodies maintain their own internal environment at a constant or steady state. Moreover, some of these hormones have even shown themselves to be the means by which certain peculiar aspects of this steady internal state is sometimes greatly upset or changed —likewise to the great advantage of the organism—and all this supplies hitherto missing information on the great problems of biologic organization and adaptation.

Precisely this last-named gain—a gain on a scientific and philosophical question which has long seemed troublesome to some scientific men—has such exceptionally wide application in the sphere of thought that it deserves a central position in this introductory statement. The knotty problems of adaptation and complex animal organization—particularly that of the brain and the regulatory processes of animals—have been thought by some biologists and philosophers to be best accounted for by the assumption of a guiding vitalistic force, a force essentially divorced from matter and akin to the supernatural. As the profound and peculiar regulatory powers of the hormones have become even partly known—particularly since these non-nervous chemical agents have been found to constitute an additional regulatory mechanism affected by both the nervous system and the external environment—the bases of the doctrine of vitalism have been sapped and severely shaken. The newer outlook conforms well with the naturalism so well stated by Darwin in his great study of 1874. And we are encouraged to proceed on the conception that an organism is to be understood, if at all, in terms of its organization, its environment, and its past. Up to now the supernatural has disclosed no sphere or place of its own in organisms.

In calling attention to these broad or general contributions of endocrinological research one should at once note that many other branches of biological or life-science are making similar, perhaps equal or greater, contributions to the present and future well-being of man. Personally I like to think of the sum of all this biological research as affording full justification for the opinion and statement of a great mathematician and chemist who for a generation was president of Harvard University and perhaps America's greatest educational leader. Near the end of his service at Harvard, President Charles W. Elliot said: "The human race has more and greater benefits to expect from the successful cultivation of the sciences which deal with living things than from all the other sciences put together."

Now lest some of my audience at once write me down as an incurable optimist, supremely satisfied with all that is labelled biological, I must add another general statement—and admission. It is this. Though our laboratories of endocrinology and of a dozen other divisions of life-science have all done well within their walls, they have failed in most of the world that lies outside those walls. The thoroughly biological thing that counts is man, the citizen—the walking, sleeping, or perhaps just now, the "sit-down" citizen; and, the future citizens now in public or other schools. These—our present and future citizens—are now left largely untouched by the best products of our biological laboratories. *We learn; but we have established only slender channels to the great stream of the mental life of modern man.* Within the time of men now alive we have learned the broad outlines of man's own nature and man's place in nature; but the citizen is unaware, and the future citizen remains practically untaught. Our very best contributions are to the mental orientation of men—yet any such contribution whatever is contingent upon contact and possession and these are not yet achieved. The laboratories have won only Pyrrhic victories until secondary schools—the only broad path to our people—begin the task of carrying basic biologic truth to our future citizens.

From these very general and introductory reflections concerning endocrinology and its biological settings we may next turn to a consideration of some quite general aspects of present knowledge of "the hormones of the anterior pituitary."

GENERAL CONSIDERATIONS

At this stage of high uncertainty concerning most that pertains to "anterior pituitary hormones" no one would elect to speak or write on that subject. You are asked to understand clearly that I have had no choice; I was drafted, and I am still reluctant. There would be only pleasure in placing before you such observations and measurements concerning some *responses* to pituitary products as have been recently accomplished in our own laboratory; but there is real danger that some opinions on pituitary hormones which I am now forced to put on record will be proved wrong even before the end of the present year. Our actual knowledge of the *hormones*—the elaborated active molecules—of this remarkable gland is so fragmentary that even our first words on the subject must include opinion and speculation. Sensing the harsh and speedy fate that awaits at least some of the speculations which must be set down in the first section of this communication I note that those paragraphs are to be regarded as my own particular view of this subject on this particular day.

To a highly significant degree the hormones of the anterior pituitary have been found to exert their action upon other hormone-producing organs. It now appears that the chief function of the pituitary is to regulate the production of chemical regulators (hormones) in other endocrine glands. The effects of pituitary hormones upon the several glands and processes of the body are both numerous and impressive. Though these effects or responses are as yet imperfectly known, and though several known responses can not yet be definitely assigned to a particular hormone, many responses have been and are now being studied with notable success. As already suggested, however, much less success has attended efforts to learn either the true number or the chemical structure of the pituitary hormones themselves. None of them has been isolated in a satisfactorily pure state; and some of the imperfect isolations accomplished from dead pituitary tissue may represent only fragments of those molecules (hormones) which pituitary cells normally release from their surfaces. These uncertainties as to the number and the chemical structure of A. P. hormones, like the now recognized difficulties encountered in their isolation and purification, are bound up with their probable protein (or polypeptid) nature and with the further complicating circumstance that more than one hormone is produced in the gland; indeed we are faced with a serious probability that more than one hormone is produced by one and the same type of pituitary cell, or even by the same cell.

While speaking of these uncertainties and probabilities we may as well discuss a possible way of regarding the production of a seeming multiplicity of hormones, or of hormone fragments, from two types of secreting cells. Much cytological study of the anterior pituitaries of higher vertebrates indicates the presence there of three special types of cells—chromophobes, eosinophils and basophils—and that only the two last-named types show secretory activity. Again, studies of responses to pituitary hormones or hormone-fragments, and also vague indications obtained from methods of isolating these pituitary products, provide some basis for grouping most or all of the secreted products into *two* groups. Thus the eosinophil cells would seem to be the source of a prolactin-adrenotropin product; and this substance probably elicits not only the responses already credited to these particular names, but also those responses designated as diabetogenic and ketogenic (and *growth* also in some animals). The basophils would seem to be the source of follicle-stimulating hormone (FSH) and probably for luteinizing and such other gonadotropic hormones or hormone-fragments as may exist (a gonadotropic contribution to the body *growth* of some animals seems also probable). Whether the thyrotropic hormone is of eosinophilic or of basophilic origin now seems only a hazardous guess. But, besides its specific capacity to stimulate the thyroid gland there is also reason to assign growth-promoting capacity (in at least some animals) to this hormone. The conception thus briefly stated requires further immediate comment.

On this view the writer does not find it necessary to allocate a "growth" hormone to either type of cell, since he believes that the unquestionable ability of the pituitary to promote bodily growth really rests upon the aggregate of helpful things contributed by other (perhaps all) pituitary hormones. This view also very definitely assigns to different pituitary hormones unequal growth-promoting rôles in different animal species—e. g., prolactin has been found of chief importance to growth in the pigeon (1, 2); thyrotropic seems of chief importance in the dwarf mouse (3); while no pituitary hormone is required for continued normal growth in some of the lower vertebrates. Again, removal of the pituitary gland (and all of its hormones) in the young rat of 25–35 grams scarcely interferes with its growth until after it reaches a weight of about 60 grams (4); and, the same "growth" extract that will promote growth in normal female rats from the 4th to 10th week of life will or may fail to promote such growth in similar male rats (5). Sex difference as well as species difference is concerned therefore in the growth response of an animal to products of pituitary origin. Of course Evans (6, 7, 8) long ago showed that adult male rats whose growth curves have plateaued can be made to grow with alkaline pituitary extracts. Finally, it is to be noted that in high degree the pituitary hormones (or hormone fragments?) have shown augmentation or synergistic actions upon each other; and one such synergism of the growth response has been observed (3) in the dwarf mouse and another on basal metabolic rate (2)—with prolactin (or prolactin-adrenotropin) and thyrotropic apparently here serving as members of the synergistic pair.

It was indicated above that the product (or products) of eosinophil cells yield many responses—those associated with prolactin, adrenal repair, glycosuria, ketosis, and a rôle in growth. The eosinophilic contribution to the growth response, in most animals, probably exceeds that of the basophilic product. Is more than one eosinophilic product liberated by the living cell? Unless thyrotropic hormone, in addition to prolactin, is of eosinophilic origin I do not think that present evidence compels us to accept even a duality of normally liberated eosinophilic products. Though there is non-negligible evidence for the existence of an adrenotropic hormone, cortical repair—like growth—may yet prove to be a response to other hormones, even involving a synergistic action of these, and not a response to a single entity. Again, it is perhaps conceivable that the structure liberated by the eosinophil cell is a molecule holding prolactin and adrenotropin in combination, and that this molecule is split into parts by the means used for their seeming (partial) isolation from the dead pituitary tissue (see below). Certainly some fragmentary information, particularly that dealing with pituitary influence on carbohydrate metabolism, suggests a close association—perhaps interrelation is the better word—of adrenal maintenance on the one hand with some of the responses to prolactin on the other.

The basophilic product—a gonadotropic complex—is probably responsible for a specific stimulation of *growth* in gametogenic tissue and in interstitial tissues, besides inducing a transformation (luteinization) of granulosa or of thecal cells of female mammals into useful but fated luteal cells (or is the latter process mediated by products originating in adrenals, gonads, etc.?). The number of hormones, or of hormone fragments, involved in regulating these responses is not clear. The status of FSH as a definite normally released product of the pituitary is conceded by all investigators. The almost complete separation of two fractions having gametogenic (FSH) and luteinizing (LH) properties has been reported by Fevold, Hisaw *et al* (9) and Wallen-Lawrence (10). Evans *et al* (11) report still other active fractions; and Smith, Engle and Tyndale (12) report fairly complete separation of one principle (LH) from pregnancy urine and another (FSH) from castrate and menopausal urine.

Since pituitary *hormones*—not *responses* to pituitary products—are the subject of this paper we must further pursue these considerations. Not only may our extraction methods pick up unfinished hormone fragments from the interior of dead pituitary cells; these methods—in addition to their known capacity to inactivate (more or less rapidly) the true hormones themselves—are perhaps also capable of both physically *separating* and of *chemically changing* two or more of the fragments that should form a molecule of a true hormone. It is improbable, though conceivable, that some apparant synergisms among pituitary products may rest therefore upon the chance given such fragments to recombine (when later put simultaneously in the blood stream) and form more of the true hormone. On *a priori* grounds there is a fair probability that some of these fragments of hormones have physiological activity, but physiological activity that is not identical with that of the entire molecule (hormone) which is normally liberated by the living pituitary cell. If this is true, our pituitary "extracts" contain a greater number of active products than of products to which the name hormone properly applies.

From what has just been stated it is clear that some importance attaches to the fact that certain pituitary hormones have been recovered from the blood. Though present failure to find certain pituitary products in the blood stream does not declare that such products are not normally liberated from the secreting pituitary cells—and therefore not true hormones—the short list of hormones that have been so recovered deserves mention.

Prolactin has been reported in post-partum human serum by Tesauro (13); our laboratory has detected it in the serum of pregnant mares, and Leblond (14) found it also in the serum of lactating mares. Geschickter and Lewis (15) found notable quantities of prolactin in cystic human mammaries and in the mammaries of post-partum cows. Leblond and Noble (16) find traces in whole fish liver and brain, and Bates and Riddle (unpublished) confirmed this result with pigeon liver. Part, but not all, of these results were obtained by the extraordinarily sensitive *local* crop-sac test of Lyons and Page (17); it is doubtful whether a test equally as sensitive as this latter test is now available for any other anterior pituitary product. Moreover, the implantation of intact untreated pituitaries of pigeons (Riddle and Schooley, 18), of fowl (Burrows and Byerly, 19) and of rats (Reece and Turner, 20) has permitted the detection of prolactin in all these untreated glands.

Follicle-stimulating hormone (FSH) is well known to be present in large quantities in the serum of mares during most of the term of pregnancy (Cole and Hart, 21). Many studies have indicated the presence of this hormone in human blood during pregnancy, and after castration or the menopause. Again, the implantation of intact untreated pituitaries of mice and rats—in the classic experiments of Smith and Engle (22) and Zondek and Aschheim (23)—supplied the original evidence that this hormone exists in the pituitary.

Luteinizing hormone (LH) extracted from urine and placenta seems to differ from that of pituitary origin. Hellbaum (24) reports the isolation from mare serum of an LH which is similar to pituitary LH. Again, the implantation of untreated pituitaries produced luteinization (22, 23)—though this alone does not establish the existence of a luteinizing hormone of pituitary origin.

Thyrotropic hormone apparently has not been satisfactorily demonstrated in the blood—probably because a sufficiently delicate test for minute amounts of it have not yet been developed. A few cc. of mare serum—very rich in FSH—were found incapable of affecting the metabolic rate of doves (2). But implantation of surviving anterior lobe to the vicinity of the thyroid has supplied evidence of the capacity of such tissue to stimulate the thyroids (Atwell, 25; Etkin, 26).

Other alleged pituitary hormones can not here be given a similar individual survey. But we note our opinion that evidence of the types (and in the volume) so easily cited for prolactin and FSH is not available for the several alleged entities: growth, adrenotropic, diabetogenic, ketogenic, fat metabolism, antagonist, interstitial cell stimulating, pancreatropic and parathyrotropic. It is true of course that less sensitive tests may have interfered with positive findings in these cases. The growth response in rats has indeed been obtained from untreated rat (and pig) pituitary implants (Smith, 27; Smith and Dortzbach, 28); but on the point here in question that result is quite indecisive since other data suggest that the growth response rests upon the sum of helpful things contributed by more than one pituitary hormone. Smith (27) was the first to show that the thyroid hormone (desiccated thyroid), added to "growth" hormone, could cause more rapid growth (hypophysectomized rats) than did the growth extract alone.

Some at least of the above list of "alleged entities" almost certainly rest upon the wholly unsubstantial basis that the injection of a pituitary extract was followed by a particular *response*, this response thereafter gratuitously supplying a name for an imagined product in the pituitary—whereas the response may in fact rest upon (a) a hormone produced in any such organ as the thryoid, gonad, adrenal, pancreas, liver, or indeed (b) upon a combined action of hormones produced in several of these organs; or, again (c), some responses thus translated into entities may rest, in part at least, upon the contamination of true anterior lobe hormone by effective amounts of intermedin or posterior lobe hormones. Few things are easier than to find a hitherto unrecognized response to the administration of mixed pituitary extracts; and few things are more difficult than to prove that the new response is produced by a hitherto unrecognized specific anterior pituitary product.

It is against the background of the preceding discussion that, for the present, it seems helpful and possible to think of two groups of substances elaborated by the pituitary; and also possible to associate the one group with the eosinophils and the other with the basophils. Since cytological phenomena within both these types of cells show waxing and waning aspects of the process of hormone formation (secretion) it seems possible that the effective molecules formed while the cell is being forced to halt secretion is not the exact equivalent of that formed under conditions which accelerate its secretory activity (thus recalling the production successively of estrone and progesterone by the same ovarian cell—or from a derivative of it). Though this concept has no experimental basis it would permit us to rationalize the production of more than one (chemically related) hormone in the same cell or type of cell. A gonadotropic chemical relative(s) of FSH, or even thyrotropic hormone, might thus arise from the basophil; again, perhaps prolactin-adrenotropin and thyrotropic might come from reverse phases of the functioning of individual eosinophil cells—some of which are in regressive phase at the moment others are highly active.

We here recall that though one is forced to speculate there should be an end to it. It is now an observed fact that an element (light) of the external environment (Rowan, 29) and the nervous system (Friedgood and Pincus, 30; Haterius and Derbyshire, 31) both share in regulating the output of at least some pituitary hormones (FSH). To this must be added important facts indicating that the production of certain pituitary hormones is affected by the output of other pituitary hormones or by secondary products of the action of a pituitary hormone. Thus a release of gonad-stimulating hormone leads to a stimulation of sex-hormones (estrone, testosterone) and these usually so act upon pituitary cells as to check or suppress the further release of FSH (Moore and Price, 32; and others), while the estrone induces a release of LH (Hohlweg, 33; Fevold, Hisaw and Greep, 34). Again, it is reported (Bates, Riddle and Lahr, 35) that prolactin (an eosinophilic product) is capable of suppressing the release of FSH (a basophilic product) in mature birds. These few instances of means of control of pituitary hormone output have wide biological significance since they permit us to begin to see the regulatory mechanism for some of the most intricate aspects of biologic organization and adaptation.

SOME RESPONSES TO SPECIFIC HORMONES

We may now consider briefly certain results recently obtained in our own laboratory which have bearing upon some of the general views already discussed. We first examine some results dealing with relationships of the prolactin-adrenotropin component (of eosinophilic origin) to carbohydrate and fat metabolism and to growth.

Data of Riddle and Dotti (36; and unpublished) show that in pigeons, doves and rabbits (apparently not in rats) the *blood sugar* is increased by injecting these animals with prolactin. Table I gives some typical findings on pigeons.

Most of the preparations used in these studies were in fact called prolactin; but certainly some of those preparations (not Nos. 380, 394H) had power to enlarge the adrenals of 21-day old rats or partially to repair the adrenal cortex of hypophysectomized pigeons. These cortical responses have been assigned to a separate substance—corticotropin—by Collip, Anderson and Thomson (37), Anselmino, Hoffman and Herold (38), Lyons (39) and Moon (40). At the moment we can exclude corticotropin or "adrenotropin" as a causative agent for the tabulated changes in blood sugar, though its presence does affect glycogen storage as noted below. We can also exclude such substances as intermedin, posterior lobe hormones, FSH, LH and thyrotropic hormone as the effective agents. Many of the effective preparations were first subjected to heat (boiling for 1 hour, or 60° C. for 5 hours).

Other data (Johnson and Riddle, unpublished) show that some of these same prolactin preparations also markedly increased the amount of histologically demonstrable *glycogen* in

TABLE I

Excerpt from data of Riddle and Dotti. Action of prolactin (3 tests of adrenotropin at bottom) on blood sugar in pigeons fasted 20–24 hours.

PREPARATION	OPERATIVE PROCEDURES USED	SINCE LAST INJECTION	NO. TESTED	DOSAGE		GLUCOSE FOUND	
				Daily	Term	Control	Test
		hrs.		units prolac.	days	mgm.	mgm.
Prolactin, #380	Normals	24	8	30	1	192	241
“ “	“	24	8	30	2	192	245
“ “	“	24	8	30	3	192	256
Prolactin, #495H	Hypct.-castrate	24	3	18	8	183	211
“ “	Hypophysectomy	24	2	18	8	188	214
“ “	Hypct.-castrate	24	1	18	8	178	225
“ “	Thyroidectomy	24	3	18	8	197	226
“ “	Partial thydct.	24	2	18	8	189	212
“ “	Hypophysectomy	25	3	18	4	187	207
“ “	Hypophysectomy	24	2	30	7	178	219
“ “	Partial adrect.	18	7	30	4	194	208
“ “	Pt. adrect.-castr.	18	2	30	4	179	225
“ “	Pt. adrect.-thydct.	18	1	30	4	192	221
“ “	Pt. adrect.-hypct.	18	2	30	4	185	219
Adrenotropic* #506	Thyroidectomy	21	3	1 (10 mg.)	4	219	232
“ “	Hypophysectomy	21	1	1 (10 mg.)	4	167	165
Prolactin, #394H	Hypophysectomy	21	3	24	4	178	214
Adrenotropic* # 576	Hyp.-pancreatectomy	4–27	2	10 (10 mg.)	1–2	229	281
Prolactin #394H	Hyp.-pancreatectomy	4–27	4	80	1–2	223	275

*As prepared by method of Lyons (39) and Moon (40) by Dr. R. W. Bates; 10 mgm. daily in all tests, and containing the amount of prolactin indicated.

For performing, and checking the completeness of the various operations on animals utilized here, we are indebted to Dr. J. P. Schooley of our laboratory.

the livers of normal and hypophysectomized birds. This response followed the use of prolactin preparations with which we could demonstrate no enlargement of the 21-day rat adrenal, though it was evidently more pronounced when preparations having capacity to enlarge such adrenals were used. This result, however, was not further increased by the use of all the hormones contained in a whole extract of the pituitary. It seems that both prolactin and adrenotropin share in one phase of carbohydrate mobilization and utilization; other available evidence (41) points to rapid enlargement of livers (also intestine and pancreas) as a true prolactin response.

Still other data (Johnson and Riddle, unpublished) clearly indicate that prolactin (adrenotropic?) also increases the *fat* content of these bird livers (which are simultaneously both enlarging and increasing their glycogen content). This increase of liver fat (in hypophysectomized pigeons) can apparently be somewhat emphasized by the adrenotropin element of whole pituitary extracts. Possibly bearing on this point is the observation that, in normal doves, the injection of *estrone* increases the amount of fat in the liver. This ovarian hormone had no apparent effect upon hepatic glycogen.

From the above one gets indications that responses traceable to the prolactin-adrenotropin complex—at one point (liver fat) associated with action of a secondary product of the FSH complex—may encompass or include responses attributed to such additional "entities" as diabetogenic, ketogenic, and fat metabolism (and pancreatropic?).

Further consideration of prolactin, or possibly of the prolactin-adrenotropin complex, will indicate that in pigeons it too is responsible for splanchnomegaly—hitherto considered an aspect of the growth response and ascribable to a "growth" hormone. The data of Table 2 show that body growth, with rapid and excessive increase of liver weight, is obtained in Carneau pigeons by the administration of relatively highly purified preparations of prolactin. At three weeks after hatching the rapidly growing young pigeon shows crop-gland stimulation from prolactin produced in its own pituitary; and at this stage it shows—in addition to an amazing rate of body growth—relative *overgrowth* in liver, intestines, and probably in the pancreas. When similar birds were somewhat older, and in growth stasis, the administration of prolactin was followed by a resumption of body growth and by overgrowth of liver and

TABLE II

Excerpt from data of Bates, Riddle, Lahr and Schooley (41). Aspects of splanchnomegaly associated with the phase of rapid growth (1.3 months) in uninjected young White Carneau Pigeons and in similar young (2.2 mo.) injected for four days with prolactin. The standard deviation of the mean is given with each averaged value.

Route of Injection	No. of Birds	Age	Daily Dose	Body Weight	Liver	Intestine: Length (Gizzard to Anus)	Intestine: Empty Weight	Thyroids	Crop-glands
		mo.	mgm.	grams	grams	cm.	grams	mgm.	mgm.
	Uninjected; youngest (1.3 mo.) group in extremely rapid growth.								
	12	1.3	....	298± 4.9	9.3±0.3	117.8±2.2	10.3±0.4	30.5±1.7	1670± 70
	15	1.5	....	457±11.6	10.0±0.3	117.8±1.4	13.2±0.4	33.3±1.5	1490± 49
	36	1.5	....	431± 5.4	9.8±0.3	115.9±1.7	10.5±0.2	32.4±1.0	1630± 53
	27	2.2	....	461±10.7	10.7±0.4	110.8±2.0	12.0±0.3	41.1±3.1	1245± 33
	Injected with iso-soluble fraction No. 474=FSH+ thyrotropic.								
Two routes*..........	10	2.2	5	453-35[1]	8.4±0.6	102.3±3.4	....	77.7±12.0	1150± 64
	Injected with iso-insoluble fraction No. 469=prolactin.								
Intravenous...........	10	2.2	1	498+15	10.7±0.5	113.1±3.4	....	42.7±2.4	1610±113
Intramuscular.........	15	2.2	1	457+24	10.8±0.6	111.1±2.9	....	40.6±1.8	2355±188
Intracutaneous........	10	2.2	1	460+43	13.3"0.9	117.3±4.6	....	40.5±1.8	3790±233
Subcutaneous..........	10	2.2	0.1	466+ 5	9.3±0.7	104.4±1.9	....	33.1±2.0	1255± 59
"	15	2.2	1	459+47	12.6±0.6	125.4±4.1	15.3±0.8	37.4±2.5	3940±232
"	10	2.2	5	453+75	16.4±0.9	127.0±4.4	....	42.0±3.6	5845±476

*Intramuscular (5) and subcutaneous (5).

[1] Gain or loss of weight is indicated for all injected birds.

intestines (still other data obtained with Drs. Schooley, Lahr and Bates show this for the pancreas, and show that these aspects of body growth and visceral overgrowth are likewise obtained in hypophysectomized pigeons). Administration of an isosoluble pituitary preparation, known to be rich in FSH and thyrotropic hormones and probably containing all anterior lobe hormones except prolactin, produced none of these effects.

Though the above-described splanchnomegaly has not been induced in the rat, by the same preparations of prolactin which produce it in doves and pigeons, positive results are regularly obtained in these latter species. The allocation to prolactin (or to heated prolactin-adrenotropin preparations) of these aspects of growth and overgrowth in these species provides a basis for further doubt as to the separateness or singleness of a "growth" hormone in the pituitary.

TABLE III

Excerpt from data of Riddle and Dotti. Effect of *cortin* (Kendall) on blood sugar of doves and pigeons fasted 20–24 hours.

ANIMAL USED (Operations Indicated)	SINCE LAST INJECTION	NO. TESTS	DOSAGE		GLUCOSE OF BLOOD PER 100 CC.	
			Daily	Term	Control	Test
	hrs.		cc.	days	mg.	mg.
Normal doves	7	12	0.3*	3–9	205	244
Normal doves	6[1]	4	0.5*	1	208	226
Normal doves	6[1]	4	0.5*	1	208	205[2]
Hypct. pigeons	6[1]	7	1.0*	1	173	193
Hypct. pigeons	6[1]	7	1.0*	1	173	175[2]
Thydct. pigeons	23	2	0.5	3–10	210	203
Part. thydct. pigeons	23	4	0.5	3–10	203	203
Thydct. pigeons	7[1]	3	1.0[1]	4	207	255
Part. thydct. pigeons	7[1]	2	1.0[1]	4	196	236
Hypct. pigeons	23	2	0.5	3–8	205	201

*Dose divided (twice daily).

[1] Intraperitoneal injection.

[2] Cortin inactivated by heat (96° C., 2 hrs.) used here.

Returning now to the rôle of the adrenal cortex in carbohydrate metabolism one first notes that Long and Lukens (see Long, 42) have shown that glycosuria is produced in cats and rats by the effective pituitary hormone (or hormones) in the absence of both the pancreas and the hypophysis, but not in the absence of the adrenals. They further found that samples of

TABLE IV

Excerpt from data of Riddle and Dotti. Effect of pituitary (top) and of sex hormones (below) on serum calcium.

PREPARATION OF HORMONE	DOSAGE		ANIMALS USED		SERUM CALCIUM (mgm. per 100 cc.)	
	Quantity Daily	Term	No.	Kind	Control	Test
	cc. or units	days			mg.	mg.
Whole A. P. extr. (all A. P. hormones)	0.3 cc.	3	6	♂♀ Hypct. juv. pigeons	9.8	11.1
Prolactin	15.0 d. u.	10	10	♂♀ Hypct. juv. pigeons	9.8	9.9
FSH (+LH?) Mare serum	0.4 cc.	9	13	♂♀ Hyp. adult pigeons	9.3	10.8
FSH (+LH?) Mare serum	1.0 cc.	6	2	♀ Partial. adrenalect., ad.	11.6	17.0
FSH+thyrotropic (from A. P.)	2 mg.	5	2	♀ Thyroidectomy, ad.	10.2	20.2
Estrone	250 R. U.	6	7	♂♀ Normal juv. pigeons	10.1	19.3
"	200 R. U.	7	2	♂ Hypct. pigeons, ad.	9.0	25.1
"	3000 R. U.	2	2	♀ Dogs	10.0	12.3
"	3000 R. U.	8	3	♀ Rabbits	12.6	13.1
Dihydroestrone	1000 R. U.	3	3	♀ Non-laying hens	12.3	22.1
"	200 R. U.	6	2	♂ Part. hypct. ad. pigeons	9.4	10.7
"	375 R. U.	7	3	♂♀ Castrate rats	10.1	10.9
Progesterone	1 Rb. U.	3	2	♂ Normal pigeon, ad.	10.2	12.0
"	0.1 Rb. U.	10	2	♀ Normal rats	10.4	11.6
Testosterone	2.5 mgm.	7	2	♂ Hypct. pigeon, ad.	9.0	8.6
"	2.0 mgm.	7	4	♂♀ Normal pigeons, ad.	10.1	9.9
"	5.0 mgm.	3	3	♂♀ Rabbits	13.1	13.1
Androstendiol	3.5 C. U.	7	2	♂♀ Hypct. pigeons, ad.	9.3	9.3

prolactin (probably with some adrenal-stimulating power) prepared in our laboratory and also adrenotropin (probably containing prolactin) prepared by Collip were both very effective in the production of glycosuria in animals with intact adrenals. Houssay and Leloir (43), however, do not regard the adrenals as necessary to this response in toads and dogs. Britton (44) has long maintained that cortin (adrenal cortical hormone) raises the blood sugar of the mammalian species studied by him. The data cited below support Britton's views and extend the observations to birds.

In Table 3 are given some data of Riddle and Dotti (36, and unpublished) showing that in doves and pigeons cortin increases the blood sugar during the first several hours after injection but that this effect disappears within less than 23 hours. Of course the pituitary hormone which stimulates the cortex would provide for a continuous secretion of cortin and thus for its continuity of action on the blood sugar. We are much indebted to Dr. E. C. Kendall, Mayo Clinic, for the cortin used in the tabulated tests. Cortin kindly supplied by Dr. David Klein, The Wilson Laboratories, and Dr. R. L. Zwemer, Columbia University, gave similar results.

These several items indicate that the diabetogenic response is, in part at least, mediated through other incretory glands, and that cortin possibly shares in this response. Cortin—as shown by the work of Hartman, of this University, and by others—contributes so much to the well-being of the organism that it is difficult to conceive its exclusion from the growth response, and particularly to that response in hypophysectomized animals. Again, Hitchcock and Grubbs (45) recently report that the administration of cortical extract to normal human beings tends to increase their muscular efficiency during light work; and this sparing of heat production may have significance in the growth process. Finally, it is not improbable that the adrenal cortex produces still other hormones than cortin, and that hitherto their effects may have helped to swell the number of products supposedly produced in the pituitary gland.

We conclude this discussion with a very brief consideration of a response obtained with an FSH component (of basophilic origin), and with the secondary products (sex hormones) of its action on the gonads. Originally this study was directed to an examination of the evidence for the production by the anterior pituitary of a special "parathyrotropic" hormone—a hormone alleged to stimulate the parathyroid glands to an increased production of parathormone, which in turn is known to increase the blood calcium.

In this study (Riddle and Dotti, 46; and unpublished data) it was soon found that prolactin and cortin were without effect, but the injection (prolonged and adequate dosage) of the FSH component into suitable animals resulted in increased amounts of calcium in the blood serum. Whole pituitary extracts gave a like result. The serum from pregnant mares, with FSH as the sole probably active factor, is effective. Later it was found that the *female sex hormones* have this power, and that male sex hormones have little or no similar action. Typical results are given in Table 4. We are greatly indebted to Dr. Erwin Schwenk, of the Schering Corporation, for the sex hormones used in that study.

Though it is uncertain whether or to what extent the parathyroids share in the response (castration prevents it) to FSH it is evident that the calcium elevating property of the sex hormones is exercised in the absence of either hypophysis, gonads, thyroids, and probably the parathyroids. It is also evident that before one can accept "parathyrotropic" pituitary hormone as an entity these new facts concerning the rôle of FSH and sex hormone must be concurrently examined.

On this day of continuous flux—along with gratifying advance—in all that pertains to the hormones of the anterior pituitary one may be neither too positive nor profitably attempt to be encyclopedic. In the present effort we have ventured—and have exposed all flanks in stating a point of view which we hope may be of momentary service. A little, but much too little, of the documentation of new research has indicated a part of the basis for an opinion that few true anterior pituitary hormones exist; that a greater variety of unfinished pituitary products exist; that secondary products of pituitary hormone action in other glands may have been mistaken for primary pituitary products; and that the true anterior pituitary hormones perhaps arrange themselves in two groups.

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BOOK NOTICES

Electricity as a Career

A high-school boy discusses his future with his father. While they are agreed on an electrical career, the methods involved in acquiring the proper training for any branch of this wide field are unknown to both of them. They enlist the aid of leading men (superintendents, etc.) in various fields: electrical engineering, radio, telegraphy, telephony, etc., who take them through plants and laboratories, and tell them of the preparation required for the different positions and the advantages accruing therefrom (disadvantages do not seem to be mentioned). No definite conclusion is reached, but the material is presented in very interesting form. The book is concluded with a list of electrical schools and colleges, radio schools, and welding schools. It is surprising to note that M. I. T. is relegated to the last named category.—J. B. Green.

Electrical Occupations, by L. A. Klinefelter. New York, E. P. Dutton & Co., 1937.

Termites

The authors have put scientific fact in plain understandable language so that many who might not otherwise know the interesting facts concerning the life, habits, and behavior of the termites can read of them in this interesting presentation. Although supposedly a book for young people, it is well adapted to older people who will find it quite entertaining. The tropical jungle is used as a setting for the discussion of the nest with its galleries, the casts, the daily activities and social life, their fossil ancestors, mating and reproduction, their guests and enemies.—D. M. DeLong.

Termite City, by Alfred E. Emerson and Eleanor Fish. Foreword by William Beebe. 127 pp. New York, Rand McNally & Co., 1937. $1.50.

Mountain Geography

Whether you are interested in mountains as places for recreation and adventure, or as land forms that present a variety of problems concerning types, agricultural possibilities, land utilization, or social and political regimes, Dr. Peattie's book is sure to stimulate your thinking, and afford a guide to the apprehension and appreciation of the multitude of environmental factors that influence mountain geography. Here is a pioneer book written for American students giving a broad survey of the results of long continued studies of European mountains, with carefully selected bibliographical notes. As stated in the publisher's note, the author makes "no attempt to preach determinism," but hopes to revive the interest of geographers in "the importance of environment rather than to confine themselves to man's part in reforming the environment."

—E. N. Transeau.

Mountain Geography, a Critique and Field Study, by Roderick Peattie. xiv+257 pp. Cambridge, Mass., Harvard University Press. $4.00.

Cicadellidae

A check list of the family Cicadellidae in North America has just been published in mimeographed form. It comprises 145 genera and more than 1800 species as mentioned in literature up to September, 1937, with distribution records and citations to the original descriptions. Included in the publication is an index to genera arranged phylogenetically.

The booklet is neatly mimeographed and well bound in a serviceable heavy paper cover.—R. H. Davidson.

Check List of the Cicadellidae (Homoptera) of North America, by Dwight M. DeLong and John S. Caldwell. 95 pp. Published by the authors, 1937. Price, $1.25. Copies may be obtained by writing Irona S. Winterrowd, Dept. of Zoology and Entomology, Ohio State University.

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